An Overview of Disarray in Vibration Analysis of Cantilever Beam with Damped Dynamic Vibration Absorber with Nonlinear Parameters

Mr. Atul S. Chougule[1] Prof. Dr. S. H. Sawant[2]
[1,2]Student
[1,2]Department of Mechanical Engineering
[1,2]Dr.J.J.Magdum College of Engineering, Jaysingpur, India

Abstract— Vibration is omnipotent, universal and multifaceted phenomena. It is an interdisciplinary field where physicist, mathematician and engineer interact in a closed loop. Vibration absorption is a method of adding a tuned spring-mass absorber to a system to create anti-resonance at a resonance of the original system. Most real-world phenomena exhibit nonlinear behavior. In these paper overviews of various works are done. This paper tries to give an idea about the previous researches and their finding about study of nonlinearity in spring, Variable Stiffness vibration absorbers and study related to vibration absorber and its application.

Key words: Vibration Absorber, Resonance, Variable Stiffness, Nonlinear Behavior

I. Introduction

The vibration absorbers are frequently used to control and to minimize excess vibration in structural systems. To reduce the vibration of the main system or machine, the frequency of absorber should be equal to excitation frequency. A beam is an elongated member, usually slender, intended to resist lateral loads by bending [1]. Structures such as antennas, helicopter rotor blades, aircraft wings, towers and high rise buildings are examples of beams. These beam-like structures are typically subjected to dynamic loads. Therefore, the vibration of beams is of particular interest to the engineer.

The stiffness of beam can be varied to adapt the changes in excitation frequencies. If forced frequencies vary from the anti-resonance frequency, their vibration amplitudes increase significantly. Then the absorber without damping cannot be applied to the structure subjected to variable frequency loads or the loads having high-frequency components. For this purpose the absorber should be tuned to excitation frequency by varying the stiffness of absorber with the help of variable stiffness mechanism. For beams undergoing small displacements, linear beam theory can be used to calculate the natural frequencies, mode shapes, and the response for a given excitation. However, when the displacements are large, linear beam theory fails to accurately describe the dynamic characteristics of the system. Highly flexible beams, typically found in aerospace applications, may experience large displacements. These large displacements cause geometric and other nonlinearities to be significant. The nonlinearities couple the (linearly uncoupled) modes of vibration and can lead to modal interactions where energy is transferred between modes [2]. By considering all above facts, this paper tries to cover literature which deals with Vibration Analysis of Cantilever Beam with Damped Dynamic Vibration Absorber with Nonlinear Parameters.

II. Numerical and Experimental Analysis of a Cantilever Beam : A Laboratory Project to Introduce Geometric Nonlinearity in Mechanics of Materials.

Tarsicio Beléndez et al. [3], published a paper on Numerical and Experimental Analysis of a Cantilever Beam: a Laboratory Project to Introduce Geometric Nonlinearity in Mechanics of Materials. The classical problem of deflection of a cantilever beam of linear elastic material, under the action of a uniformly distributed load along its length (its own weight) and an external vertical concentrated load at the free end is experimentally and numerically analyzed. The experiment described in this paper is an easy way to introduce the concept of geometric nonlinearity in mechanics of materials. The ANSYS program is used to numerically evaluate the system and calculate Young's modulus of the beam material. Finally, they compared the numerical results with the experimental ones obtained in the laboratory.

III. Design of Dynamic Vibration Absorber for Vibration Isolation of Beams Under Point or Distributed Loading

W.O.Wong et al. [4], have developed a Dynamic Vibration Absorber by Combining a Translational-Type and Rotational-Type Absorber for Vibration Isolation of Beam Under Point or Distributed Harmonic Excitation. Finite element analysis and Euler– Bernoulli beam theory was used for evaluation of the performance of vibration isolation of the proposed absorber mounted on a beam.The traditional dynamic vibration absorber is an auxiliary mass-spring system which, when correctly tuned and attached to a vibrating system subjected to harmonic excitation, causes to cease the steady-state motion at the point to which it is attached. It has the advantage of providing a cheap and easy-to-maintain solution for suppressing vibration in vibrating systems with harmonic excitation. However, when applying dynamic vibration absorber to a continuous structure such as a beam, vibration can be eliminated only at the attachment point of the vibrating beam while amplification of vibration may occur in other parts of the beam. Researches on suppressing vibration in a region or the whole span of a beam structure by using the dynamic vibration absorber have been reported recently. These methods require the use of many translational-type mass-spring absorbers for creating a region of nearly zero amplitude in the beam structure. In this paper, it is proved that a region of zero amplitude in the beam structure can be obtained if a translational-type absorber and a rotational-type absorber are combined as one and attached at a suitable location on a beam structure under distributed or point load of harmonic excitation. The performance of the proposed absorber for vibration isolation in beam structures was investigated via finite element analysis and verified by numerical and experimental tests.

IV. Vibration Control of a Structure by Using a Tunable Absorber and an Optimal Vibration Absorber under Auto-Tuning Control

K.Nagaya et al. [5], illustrated a Variable Stiffness Vibration Absorber used for controlling a principal mode. Vibrations of machines and structures vanish perfectly at a certain frequency when they have a vibration absorber without damping. But if forced frequencies vary from the anti-resonance frequency, their vibration amplitude increases significantly. Then the absorber without damping cannot be applied to the structure subjected to variable frequency loads or the loads having high-frequency components. The present article discusses a method of vibration control of a structure by using the vibration absorber without damping. In this method, a variable stiffness vibration absorber is used for controlling a principal mode. The stiffness is controlled by the microcomputer under the auto-tuning algorithm for creating an anti-resonance state. The optimal vibration absorber with damping is also utilized for controlling higher modes. The analyses and the algorithm for the auto-tuning control are developed. A method to obtain optimal parameters has been presented for the vibration absorber which controls higher modes. In order to validate the control method and the analysis, experimental tests have been carried out.

V. Vibration Reduction of Beams under Successive Traveling Loads by Means of Linear and Nonlinear Dynamic Absorbers

Farhad S. Samani and Francesco Pellicano [6], presented the work to assess the Performances of Dynamic Vibration Absorbers (DVA's) in Suppressing the Vibrations of a Simply Supported Beam Subjected to an Infinite Sequence of Regularly Spaced Concentrated Moving Loads. In particular, several types of DVA are considered: linear, cubic, higher odd-order monomials and piecewise linear stiffness; linear, cubic and linear-quadratic viscous damping. The purpose is to clarify, if nonlinear DVAs show improvements with respect to the classical linear devices. The dynamic scenario is deeply investigated in a wide range of operating conditions, spanning the parameter space of the DVA (damping, stiffness). Nonlinear stiffness can lead to complex dynamics such as quasi-periodic, chaotic and sub-harmonic responses; moreover, acting on the stiffness nonlinearity no improvement is found with respect to the linear DVA. A nonlinear non-symmetric dissipation in the DVA leads to a great reduction of the beam response, the reduction is larger with respect to the linear DVA.

VI. Supercritical Vibration of Non-Linear Coupled Moving Beams Based on Discrete Fourier Transform

H. Ding et al. [7], published a paper on Supercritical Vibration of Nonlinear Coupled Moving Beams Based on Discrete Fourier Transform. Natural frequencies of nonlinear coupled planar vibration are investigated for axially moving beams in the supercritical transport speed ranges. The straight equilibrium configuration bifurcates in multiple equilibrium positions in the supercritical regime. The finite difference scheme is developed to calculate the non-trivial static equilibrium. The equations are cast in the standard form of continuous gyroscopic systems via introducing a coordinate transform for non-trivial equilibrium configuration. Under fixed boundary conditions, time series are calculated via the finite difference method. Based on the time series, the natural frequencies of nonlinear planar vibration, which are determined via Discrete Fourier Transform (DFT), are compared with the results of the Galerkin method for the corresponding governing equations without nonlinear parts. The effects of material parameters and vibration amplitude on the natural frequencies are investigated through parametric studies. For the transverse integro-partial-differential equation the equilibrium solutions are performed analytically under then fixed boundary conditions. Numerical examples indicate that the integro-partial-differential equation yields natural frequencies closer to those of the coupled planar equation.

VII. Concept and Model of Eddy Current Damper for Vibration Suppression of a Beam

Henry A. Sodano et al. [8], presented the study on a New Electromagnetic Damping Mechanism. Electromagnetic forces are generated by the movement of a conductor through a stationary magnetic field or a time varying magnetic field through a stationary conductor and can be used to suppress the vibrations of a flexible structure. In the present study, a new electromagnetic damping mechanism is introduced. This mechanism is different from previously developed electromagnetic braking systems and eddy current dampers because the system investigated in the subsequent manuscript uses the radial magnetic flux to generate the electromagnetic damping force rather than the flux perpendicular to the magnet's face as done in other studies. One important advantage of the proposed mechanism is that it is simple and easy to apply. Additionally, a single magnet can be used to damp the transverse vibrations that are present in many structures. Furthermore, it does not require any electronic devices or external power supplies, therefore functioning as a non-contacting passive damper. A theoretical model of the system is derived using electromagnetic theory enabling us to estimate the electromagnetic damping force induced on the structure. The proposed eddy current damper was constructed and experiments were performed to verify the precision of the theoretical model. It is found that the proposed eddy current damping mechanism could increase the damping ratio up to 150 times and provide sufficient damping force to suppress the beam's vibration quickly.

VIII. Analysis and Comparison of Vehicle Dynamic System with Nonlinear Parameters Subjected to Actual Random Road Excitations

Prof. S. H. Sawant and Dr. J. A. Tamboli [9], published a paper on Analysis and Comparison of Vehicle Dynamic System with Nonlinear Parameters Subjected to Actual Random Road Excitations. Paper investigates the importance of effects depend upon the degree of nonlinearity and so the effect on the response. In this paper, nonlinearity in mass, spring and damper are considered and compared for their individual and relative significance. Also, it is studied how nonlinearity affects the response compared to linear system. The theories of nonlinear dynamics are applied to study nonlinear model and to reveal its nonlinear vibration characteristics. Thus this paper deals with comparison between simulation results obtained for passive and semi-active linear systems with nonlinear mass, spring and damper. The excitation is taken as actual random road excitation to achieve improved performance. Thus, the emphasis is to study the nonlinearities in mass, spring and damper for passive suspension system performance and compare the reactive significance.

IX. CONCLUSION

From the literature survey it is seen that the research on beam started from developing linear beam theory to calculate the natural frequencies, mode shapes, and the response for a given excitation it is observed that in order to control the vibration of beam Variable stiffness vibration is more effective .In order to carryout vibration analysis of damped dynamic vibration absorber system for variable stiffness it is necessary to carry out analysis with nonlinear parameters.

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