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An Overview of Disarray in Vibration Analysis of Undamped Dynamic Vibration Absorber

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ABSTRACT

There are numerous sources of vibration in an industrial environment: in processes such as pile driving and blasting; rotating and reciprocating machinery such as engines, Compressors, and motors; transportation vehicles such as trucks, train and aircraft; the flow of fluids; and many others. 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 & their finding about study of nonlinearity in spring, Static analysis of spring and study related to vibration absorber and its application.

Keywords: Vibration Absorber, Resonance, Nonlinear behavior.

I. INTRODUCTION

In vibration analysis, a dynamic vibration absorber is a tuned spring-mass system which reduces or eliminates the vibration of harmonically excited system. Rotating machines such as engines, motors and pumps often incite vibration due to rotational imbalances. A dynamic absorber can be affixed to the rotating machine and tune to oscillate in such a way that exactly counteracts the force from rotating imbalance. This reduces the possibility that a resonant condition will occur which may cause rapid catastrophic failure.

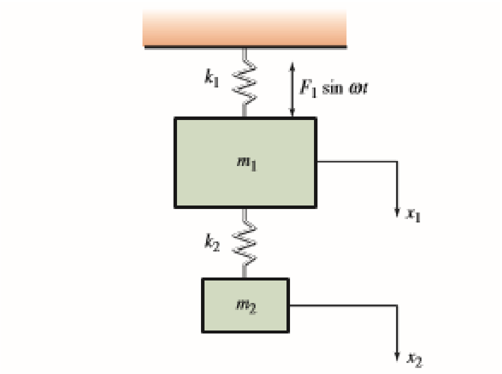

Figure 1 : Two DoFUndamped Dynamic Vibration Absorber

For the system shown in figure let us assume $x_2 > x_1$, Spring mass system k_1-m_1 as main system and Spring mass system k_2-m_2 as absorber system.

Equations of motions for Two DoF system are as follows,

$$m_1 \ddot{x}1 + Fo \sin \omega t = -k_1 x_1 + k_2 (x_2 - x_1) \quad (1.1)$$

$$m_2 \ddot{x}_2 = -k_2 (x_2 - x_1) \quad (1.2)$$

Assuming solution under steady state condition,

$x_1 = X_1 \sin\omega t$

$x_2 = X_2 \sin\omega t$

finally we get equation in dimensionless form as

$$\frac{x_1}{xst} = \frac{1 - \frac{\omega}{\omega 2^2}^2}{\frac{\omega^4}{\omega 1^2 \omega 2^2} - \left[(1+\mu)\frac{\omega}{\omega 1^2}^2 + \frac{\omega}{\omega 2^2}^2\right] + 1} \quad (1.3)$$

$$\frac{x_2}{xst} = \frac{1}{\frac{\omega^4}{\omega 1^2 \omega 2^2} - \left[(1+\mu)\frac{\omega}{\omega 1^2}^2 + \frac{\omega}{\omega 2^2}^2\right] + 1} \quad (1.4)$$

From this equations it is clearly seen that $x_1 = 0$, when $\omega = \omega_2$ i.e. When excitation frequency is equal to the natural frequency of the absorber system, the main system amplitude becomes zero even though it is excited by harmonic force. The principle of an undamped dynamic vibration absorber.

Also it can be seen that when $\omega = \omega_2$, we get

$$Fo = -k_2x_2 \tag{1.5}$$

The above equation shows that the spring force $k_2x_2$on main mass due to amplitude x_2 of absorber mass is equal and opposite to the exciting force on main mass resulting in no motion of main system. This is basis for the vibration absorber.[1]

Most real-world phenomena exhibit nonlinear behavior. There are many situations in which assuming linear behavior for physical system might provide satisfactory results. On other hand, there are circumstances or phenomena that require a nonlinear solution. A nonlinear structural behavior may arise because of geometric and material nonlinearities, as well as change in the boundary conditions and structural integrity. A nonlinear spring has a nonlinear relationship between displacement and spring force. A graph of spring force vs. displacement for a nonlinear spring will be more complicated than a straight line, with a changing slope. As nonlinear springs have different load-deflection characteristics than the linear spring there will be difference in the amplitude of main mass obtained by theoretical and experimental methods. Nonlinearity in mass and spring will be considered. The nonlinearity in mass arises when mass moves with certain velocity, which is due to change in mass density of the fluid around it. Nonlinearity in spring is due to large deflection of it, which is geometric nonlinearity.

In recent decades with development in mathematics and computers very efficient FEM software's were developed (E.g. – ANSYS, Abaqusetc). These software's in combination with high computational powered work stations (computers) are working very efficiently. But for using FEA software, highly experienced people are required because a small mistake in assumption or applying boundary condition may be cause of larger error in results. Most important thing about FEA is that results which are inaccurate as well as correct, may be displayed in colored image

By considering all above facts, this paper tries to cover literature which deals with analysis of undamped dynamic vibration absorber subjected to harmonic excitation with nonlinear parameters.

II. LITERATURE REVIEW

Many of researchers have contributed in development of theories of vibration analysis. ZuoShuguang et al. published paper on A finite element analysis of the barrel-shaped Helical Spring on the Vehicle Rear Suspension

They have analyzed the barrel shaped helical spring on the rear suspension of passat b5. The accurate 3D model of spring is built. Then the stiffness of spring is calculated by finite element analysis. The results of FE analysis are validated by experimental method. The barrel shaped spring used is showing nonlinear phase during compression which can improve the stability of vehicle [2].

MaximeGeeroms, Laurens Marijns of Ghent University, Department EESA, Belgium carried out work on nonlinear vibration absorber. They found that linear vibration absorbers can only capture certain discrete frequencies. Therefore the use of nonlinear vibration absorbers which can capture a whole range of frequencies is investigated as an alternative. Such a nonlinear vibration absorber has some special characteristics. For example there is certain frequency-energy dependence. To investigate nonlinear dynamical systems there is a need for new methods. The harmonic balance method is such a method and is discussed. The idea is to substitute a Fourier series expansion of the solution variables into the system equations and 'balance' them. Furthermore two realizations of a nonlinear energy sink as an example of a nonlinear vibration absorber are discussed. One based on the restoring force in a wire, the other one by forcing a linear spring to follow a certain path. As will be discussed, an analog principle can be used for the realization of a Duffing type of nonlinear absorber [3].

Prof. H.D. Desai and Prof. Nikunj Patel published a paper on Analytical and Experimental Investigation of a Tuned Undamped Dynamic Vibration Absorber in Torsion. In this paper design and development of experimental setup for determining the response characteristics of torsional, tuned, undamped, dynamic vibration absorber is presented. A mathematical model for the absorber with base excitation is developed and the theoretical values of the torsional amplitude are calculated for different values of excitation frequency. The theoretical and experimental results are correlated.

The theoretical and experimental results are superimposed for both the single degree of freedom system and absorber respectively. From these graphs it can be observed that a correlation exists between theoretical and experimental results but due to nonlinearities exists in the system itself, the experimental and theoretical results doesn’t exactly matches [4].

Yung-sheng Hsu, Neil S Ferguson have investigated the physical behaviour and effectiveness of a nonlinear dynamic vibration absorber (NDVA). The nonlinear absorber considered involves a nonlinear hardening spring which was designed and attached to a cantilever beam excited by a shaker. The cantilever beam can be considered at low frequencies as a linear single degree-of-freedom system. The nonlinear attachment is designed to behave as a hardening Duffing oscillator. The nonlinearity of the attachment is due to the particular geometrical configuration undergoing a large amplitude response. The experiment investigated the potential for vibration reduction of the system. Analytical and numerical results are presented and compared. From the measured results it was observed that the NDVA had a much wider effective bandwidth compared to a linear absorber. The frequency response curve of the NDVA has the effect of moving the second resonant peak to a higher frequency away from the tuned frequency so that the device is robust to mistuning.

This paper has also investigated the influence of the NDVA parameters on the vibration reduction. The nonlinearity resulted in a much wider effective bandwidth compared to that for a linear absorber with similar mass and damping. It was found that the frequency response curve of the NDVA has the effect of moving the second resonant peak to a higher frequency away from the tuned frequency, so that the device is robust to mistuning. Experimental results have been presented to compare with the model derived [5].

Irshad M. Momin Dr. Ranjit G. Todkar published a paper on Design and Development of A Pendulum Type Dynamic Vibration Absorber for A Sdof Vibrating System Subjected to Base Excitation

The use of centrifugal pendulum for dynamic vibration absorber design (CPVAs) is a proven method for reducing undesired torsional vibrations in rotating systems. These devices are in use for many years, most commonly in light aircraft engines, helicopter blade rotors etc. These devices have also been reported for reduction of rectilinear vibrations. Pendulum type dynamic vibration absorbers use impact forces for effective reduction of rectilinear vibrations describing modeling method and transient state analysis in view of spring impact absorbers, floating impact absorbers and pendulum impact absorbers. Bond graph technique for modeling of SDOF vibrating system excited by rotating unbalance at the sprung mass using a pendulum type dynamic vibration absorber is reported in the recent literature. This paper deals with the modeling and design procedure for a centrifugal pendulum type dynamic vibration absorber (CPVA) subjected to base excitation. This paper presents a detailed analysis and experimental investigations of the effect of parameters affecting the motion transmissibility of the sprung mass such as size of the pendulum mass, eccentricity of the pendulum pivot with respect to axis of rotation of the pendulum assembly, mass ratio (ratio of the pendulum mass to the sprung mass), gear ratio (the ratio of the pendulum rotational frequency to the excitation frequency) and the frequency ratio (the ratio of the excitation frequency to the natural frequency of the SDOF system). It has been proved that the CPVA is effective in reduction of motion transmissibility of the sprung mass of the SDOF system with the proper selection of the affecting parameters [6].

Yu chengsu, Dr.Yuyilin submitted a thesis on Modeling, Verification, Optimal Design of Nonlinear Valve Spring. The objective of their study was optimal design of helical spring based on dynamic criteria. The most important dynamic performance criterion of a helical spring is the resonance behavior, including dynamic stress, coil closing, and surge. More design variables are also making the description of dynamics more complex. In this study, predictive dynamic models for variable pitch angle, wire diameter, and spring radius are derived by fundamental mathematics and mechanics principles. These models are nonlinear partial differential equations, in general more complex than the well-known and commonly used wave equation. Numerical solution of these dynamic models is also called dynamic simulation.

In this study, finite difference method combined with moving boundary solutions are applied to obtain the dynamic response. Dynamic responses as a time domain, discrete data from various models are compared with data from physical dynamic experiments to verify the accuracy of the models, and to improve the parameters in the dynamic models. Fast Fourier Transform (FFT) is utilized as a tool to evaluate severity of resonance in different models and in optimization process. To verify that the use of finite difference in the simulation process is providing stable and reliable results, the numerical solutions are compared with solutions obtained using ABAQUS-MATLAB programs. Results in terms of system eigenvalue calculation obtained by different programs, either commercial or Finite Difference Method (FDM), showed very good agreements. Numerical optimization results obtained in this study also showed that it is worthwhile to introduce more design variables to increase the flexibility in an optimal design process for obtaining better results [7].

III. CONCLUSION

By the literature review it is seen that importance of nonlinear analysis and various methods of static analysis of spring. In earlier re-searches linear parameters of vibration absorber were considered but in practice the spring with nonlinear characteristic. As Most real-world phenomena exhibit nonlinear behavior. So it is important to consider the nonlinearities of spring while designing the vibration absorber . With MATLAB analysis of undamped dynamic vibration absorber effect of nonlinearity in spring on main mass and absorber mass displacement will be compared. So, finally it will bestated that instead of making more expensive and time consuming experimental verification of dynamic system MATLAB analysis will lead to results closer to real life analysis. For the designing or analyzing of dynamic model, nonlinear parameters should be more concentrated to get the real life results.

IV. REFERENCES

[1] S. S. Rao, “Mechanical Vibrations”, 3rd ed. Addison-Wesley Publishing Company (1995).

[2] Lei, ZuoShuguang, Yang Xianwu, Wang Jirui, “A Finite Element Analysis of the Barrel-Shaped Helical Spring on the Vehicle Rear Suspension” ICCDA Vol 2, 2010.

[3] MaximeGeeroms, Laurens Marijns, Mia Loccufier and Dirk Aeyels, “Design of A Nonlinear Vibration Absorber”, Ghent University, Department EESA, Belgium.

[4] Prof. H.D. Desai, Prof. Nikunj Patel, “Analytical and Experimental Investigation of a Tuned Undamped Dynamic Vibration Absorber in Torsion”, Proceedings of World Congress on Engineering (WCE2010), vol. II, 2010.

[5] Yung-Sheng Hsu, Neil S Ferguson, “The Experimental Performance of A Nonlinear Dynamic Vibration Absorber”, Proceedings of IMAC XXXI Conference and Exposition on Structural Dynamics, USA, 2013.

[6] Irshad M. Momin, Dr. Ranjit G Todkar, “Design and Development of A Pendulum Type Dynamic Vibration Absorber for A SDoF Vibrating System Subjected to Base Excitation”, International Journal of Mechanical Engineering and Technology (IJMET), pp.214-228, September-December 2012.

[7] Yu chengsu, Dr.Yuyilin, “Modeling, Verification, Optimal Design of Nonlinear Valve Spring”.