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Design and Development of Tuned Vibration Absorber

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ABSTRACT

Optimum design of Tuned vibration absorber here parameters such as mass ratio (μ) need to be optimally selected to realize satisfactory performance of the system. Experimentation provides valuable insight in dynamical behaviour and gives understanding of said dimensionless parameters. It is observed that minor changes integrate very accurate results. The main objective of this paper was to design and develop an experimental set up to study the principal of tuned vibration absorber.

Keywords: Parent system, Auxiliary system, vibration absorber.

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I. INTRODUCTION

Vibrations maybe desirable or undesirable depending upon the need. The examples of desirable vibrations are string musical instruments while the undesirable vibrations are vibratory motions of engine, electric motors, machinery in industries etc. Undesirable vibration wastes energy and creates unwanted sound, noise.

The vibration absorber is a mechanical device used to reduce or eliminate unwanted vibration. It consists of an auxiliary system attached to the main system that needs to be protected from excessive vibration. Thus the main system and the attached system will have two natural frequencies.

The vibration absorber is commonly used in machinery that operates at constant speed, because it is tuned to one particular frequency and is effective only over a narrow band of frequencies. Common applications of the vibration absorber include reciprocating tools, such as saws and sanders, and compactors, large reciprocating internal combustion engines and pumps which run at constant speed. In these systems the vibration absorber helps balance the reciprocating forces. Without a vibration absorber, the unbalanced reciprocating forces may make the device impossible to hold or control.

II. LITERATURE REVIEW

Vibration absorbers are devices attached to flexible structures in order to minimize the vibration amplitudes at a specified set of points. Design of vibration absorbers has a long history. First vibration absorber proposed by Frahm in 1909 [Den Hartog, 1956] consists of a second mass-spring device attached to the main device, also modelled as a mass-spring system, which prevents it from vibrating at the frequency of the sinusoidal force acting on the main device[1].

If the absorber is tuned so that its natural frequency coincides with the frequency of the external forcing, the steady state vibration amplitude of the main device becomes zero. From a control perspective, the absorber acts like a controller that has an internal model of the disturbance, which therefore cancels the effect of the disturbance.

The tuned vibration absorber (TVA) has been used for many years since its inception by Ormondroyd and Den Hartog (1928). The device is an auxiliary spring– mass–damper system whose natural frequency ('tuned frequency') is tuned to suppress the vibration at its point of attachment to a host structure [2].

In the industry, it has been primarily used to suppress vibration caused by a resonance condition in machinery. A tuned mass vibration absorber consists of a spring-mass system installed on a vibrating machine. In its basic form, its natural frequency is tuned to match the natural frequency of the machine it is installed on. Because of this tuning a TVA exerts a force on the main system that is equal and opposite of the excitation force, cancelling vibration at the resonant frequency. In modern applications, the goal is to assure the performance within specifications over a wide frequency range while minimizing the size of the device.

III. DESIGN CONSIDERATIONS

To design a mechanical system, some design considerations are made which fulfil the limitations of sources as well as expectations from the system. The same thing was done while designing absorber system.
The various considerations for this design were as follows:

1. The designed absorber system should be able to withhold all the stresses which are expected to occur during experiment. Also, it should not be over-weight i.e. it should be as optimized as possible.

2. Since the vibrations of parent system are absorbed by auxiliary system, there are some vibrations in auxiliary system.

3. These vibrations should be of minimum possible amplitude.

4. The designed vibration absorber should be feasible to manufacture.

5. The designed system should be of minimum possible cost.

IV. DESIGN OF TVA

The experimental setup of Tuned vibration absorber consists of two systems:
1. Parent system
2. Auxiliary system.

The actual experimental setup consists of a parent system and an auxiliary system. The auxiliary system is attached exactly below the rotary disc of the parent system.

Fig. Parent System

Parent system consists of a cantilever beam, a rotary disc with an unbalance and a spring. The beam is fixed at one end of a frame. There is an adjustable link which can be put on the cantilever beam. It has a threaded hole on its lower side whereas disc attached on one side. This link is kept at mid-point of cantilever beam. On the other end of cantilever beam, there is a spring attached to it and it's another end is connected to the upper side of the frame.
The auxiliary system is attached to the cantilever beam of parent system below the rotary disc. Auxiliary system consists of a cantilever beam and mass. The mass is attached at the free end of cantilever beam.

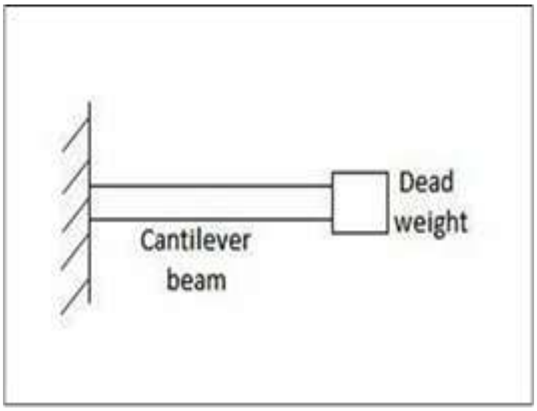

Fig. Auxiliary System

V. WORKING

The experimental setup consists of parent system and auxiliary system. In parent system, a rotary disc is mounted on the cantilever beam. The cantilever beam is supported by a spring at its free end as shown in the figure. The rotary disc rotates when power supplied through a motor. The disc rotates at the frequency of external force which is a centrifugal force generating vibrations due to an unbalance on the disc in the system. Also the beam has its own natural frequency.

Whenever the frequency of excitation coincides with the natural frequencies of the beam, resonance occurs. The most prominent feature of the resonance is a large displacement. In most mechanical and structural systems, large displacements indicate undesirably large strains and stresses, which can lead to the failure of the systems.

In many practical situations, it is possible to reduce but not eliminate the dynamics forces that cause vibrations. Several methods can be used to control vibrations. Amongst this method, one of the methods is attaching an auxiliary system. The auxiliary system consists of a cantilever beam and mass. This auxiliary system is known as absorber mass system. This absorber system avoids resonance by tuning, therefore avoids the damage of mechanical systems. The absorber mass system is operative only when the natural frequency of the parent system, excitation frequency and the natural frequency of the absorber mass system are equal.

The rotary disc is operated by a motor. Because of the unbalance on the disc, centrifugal force acts on the rotary disc. The excitation frequency of the external force acting on the cantilever beam, $F_o \sin\omega t$ matches with the natural frequency of cantilever beam, resonance occurs and the amplitude of vibration of system drastically increases. To reduce these vibrations an auxiliary system is attached to the parent system having natural frequency equal to both the excitation frequency as well as the natural frequency of the cantilever beam. The auxiliary system absorbs the vibrations of parent system and it starts vibrating with the much lesser amplitude than that of parent system.

VI. CONCLUSION

The auxiliary system successfully absorbs the vibrations of the parent system and reduces the amplitude of the parent system to a great extent. However the range of absorption is narrow and the optimum mass ratio must be selected for best results.

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