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ADAPTIVE TUNED DYNAMIC VIBRATION ABSORBER

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Abstract - *The aim is to investigate the use of a Dynamic Vibration Absorber to control vibration in a beam. Traditional means of vibration control have involved the use of passive and more recently, active methods. This study is different in that it involves an adaptive component in the design of vibration absorber using a novel design of cantilever beam mechanism. The design incorporates the use of two concentrated masses cantilevered from two rods. The adaptive solution is achieved by moving the two masses along the length of the rod, producing a changing natural frequency for the absorber device. For this the beam with Young's modulus of 207*10^(9) Pa, density of 7800Kg/m^(3),width of beam (b)=0.025 m, height of beam (h)=0.05m & length of beam (l)=1.135 m is used. This system is applied to a frequency range of 30 to 80Hz.*

Keywords *- Vibration absorber, dual cantilever mass, active and passive absorber, an ideal absorber.*

I. INTRODUCTION

In an engineering application there may be one or multiple motion / power transferring elements. There may be linear, sliding or rotary elements. For any such element, while transferring power/motion there are certain amount of vibrations which are caused. The cause of vibrations may be: - Unbalanced configuration of the system itself, inaccurate machining, improper tolerances of dimensions etc.These vibrations may cause many problems in operation and it may lead to failures too. So it is very necessary to eliminate these vibrations in order to achieve a perfect stable system for power transmission.

Vibration elimination

Vibrations can be eliminated either completely or partially by attaching an additional system to our element. We can use various dampers, isolators or Absorbers. Damper is a system having very high damping, so the amplitude of vibration decreases by a large amount by adding such stiffness or damping element to our existing system. Isolators are the system which tries to isolate the element or the existing system in order to decrease or completely eliminate the vibrations in our element. While absorbers are the systems that decrease the amount of vibrations simply by using the concept of negative superposition. Superposition is the process of adding the existing vibrations with the vibrations caused by an external system.

Vibration absorber

Basically there are categories based on nature of frequency and dynamic characteristic of vibration absorbers. On the basis of Nature of frequency the vibration absorber may be Dynamic vibration absorber or static vibration absorber (Tuned vibration absorber).The basic difference between both of these are: In Dynamic vibration absorber the absorbing system senses the vibrations, gives actuating signal accordingly and absorbs vibration in a very high range of frequencies. While for tuned vibration absorber: It is only tuned for a particular frequency and it cannot be used for wide range of frequencies. In the classification based on the dynamic characteristic of vibration absorber may be of: 1) Active vibration absorber, 2) Passive vibration absorber. In passive type dynamic absorber system there is one more advantage that is we only get positive damping and not the negative damping in order to achieve only decrease in vibration magnitude. So, our design is based on: Adaptive passive dynamic tuned vibration absorber.

As explained earlier the absorber is a system which tries to eliminate vibrations by negative superposition. Basically what happens is:

Suppose the nature of my vibrations occurring on an element is

$$X(t) = A \sin(wt+Q)$$

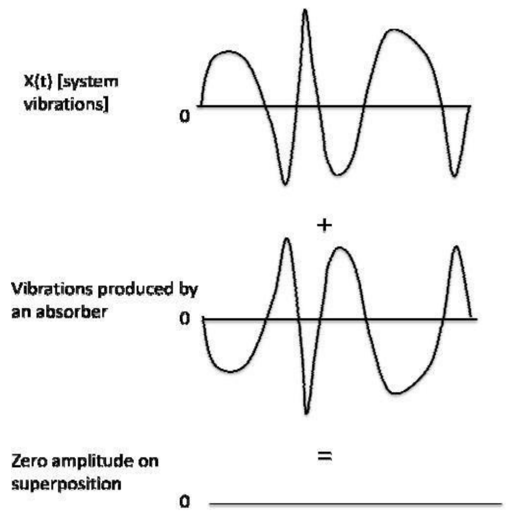
So, we can add a particular system which has same nature of vibration function by opposite nature:

X'(t)= -A sin(wt+Q) So

x(t)+x'(t) = 0

From this example we can say that a perfect vibration absorber absorbs the vibration totally and makes the vibration free The diagram below shows the nature and tendency of an ideal or perfect absorber:

Figure 1 Vibration Elimination



II. CONCEPTUALIZATION

The design approach for the adaptive passive tuned dynamic vibration absorber is to make it of the design of double cantilever type. The design is based on strength and further the length of the cantilever beams are designed based on the natural frequency to be obtained. The double cantilever structure is attached to several other components to make it sense the vibration and actuate thereafter. There is a column that supports two cantilever beams containing two point masses as shown in figure.

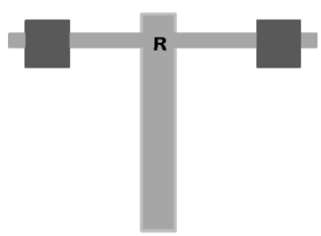


Figure 2. Basic structure of cantilever beam

The point masses suspended creates a bending and due to that there is also a stiffness of this structure. Due to this stiffness there is a natural frequency of the structure itself and thus w e can calculate various lengths in order to damp a vibrating system. There are two point masses at the two extreme points of the rods. Two rods are being used one is threaded and another one is normal rod to constraint the rotational motion of the point mass when the threaded rod is given actuation using motors. For complete vibration absorption we must assure that the vibration absorber system is vibrating on its 1st mode. There may be several modes in which the system may be vibrating.

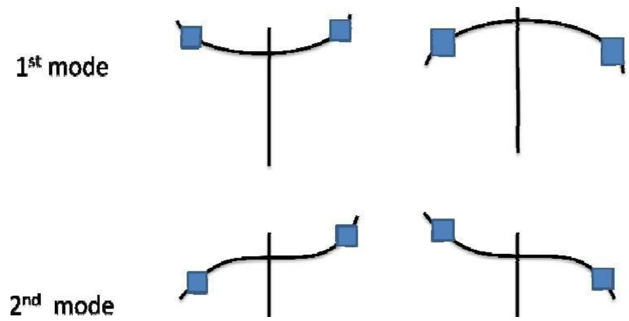


Figure 3 Modes of vibration

III. EXPERIMENTAL SETUP WITH ABSORBER ON THE BEAM

In the setup, the absorber device is acting as two cantilevers with a concentrated mass attached to the end of each. Each cantilever acts as a beam which is initially loaded at one end and clamped at the other. The theoretical analysis of this has been described previously. The shaker is attached to the beam such that it is able to move along the beam for different point source locations. This will assist in the study of the effect of source location on the frequency response of the absorber. The absorber itself is attached to the beam via clamps. Similarly, this allows the location of the absorber to be changed to produce a favorable output signal from the accelerometer.

It is assumed that the fundamental mode of vibration contributes the most towards the overall vibration in the beam. **The absorber is located slightly off-centre on the beam, to allow it to respond to the first and second modes of vibration. However, the second mode is not aimed to be controlled by the absorber in this experiment**. The setup is illustrated in figure. The length of the beam was arbitrarily chosen such that the resonance frequency of the beam would be near the operating range of the absorber. This value was calculated using Euler equations for beams. The fundamental frequency for a simply supported beam is given by,

$$\omega_1 = (\beta l)^2 \sqrt{\frac{EI}{\rho A l^4}} \qquad for \qquad (\beta l)^2 = 9.87$$

$$I = \frac{bh^3}{12} = \frac{0.025 \times 0.05^3}{12} = 2.6 \times 10^{-7} m^4$$

$$\rho A = 9.75 kg / m$$

$$\omega_1 = 9.87 \sqrt{\frac{207 \times 10^9 \times 2.6 \times 10^{-7}}{9.75 \times 1.35^4}}$$

$$= 402 rad / s$$

Beam Configuration	$(\beta_1 l)^2$	$(\beta_2 l)^2$	$(\beta_3 l)^2$
Simply Supported	9.87	39.5	88.9
Cantilever	3.52	22.0	61.7
Free-Free	22.4	61.7	121.0
Clamped-Clamped	22.4	61.7	121.0
Clamped-Hinged	15.4	50.0	104.0
Hinged-Free	0	15.4	50.0

Table No. 1 Typical end conditions for beam

IV. CONTROL SYSTEM

Controller Setup

The aim of the work described in this study is to produce an absorber which is tunable "on-line", to provide an alternative to the actuators currently used in active vibration control and structural / acoustic control. Adjustment of the resonance frequency of the cantilever beam absorber can be made via adjustment of the location of the masses on the shafts.

The hardware used to facilitate movement of the absorber mass in and out on the shafts consists of a stepper motor. The stepper motor is connected to the main shaft of the mass by a set of worm gears. There are 2 accelerometers used in the system; one located on the absorber mass to determine the natural frequency at which the absorber is tuned, and the second is attached to the beam to measure the excitation frequency.

The Linear Transducer

The position of the absorber mass at any point in time is known by incorporating a linear transducer into the design of the device. This linear transducer consists of a rotational pot which gives out a voltage variation depending on the number of turns it has completed. A tensional spring is built into the transducer so that it will recoil whenever the absorber mass is moving inwards along the rod. The pot is connected to one of the masses via a string which is glued to the surface. The arrangement can be shown in figure. The output of the transducer is passed through a power amplifier and the signal is converted to a DC voltage.

V. CONCLUSION

A dual cantilevered mass absorber, which uses cantilevered beams and concentrated masses, has demonstrated to be very effective in controlling the vibration in a simply supported beam. This arrangement has been shown to be capable of being incorporated for adaptive use. Effective attenuation has been achieved with this absorber and further work will be planned for this device

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