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Design and Development of Experimental Setup for Two Degrees of Freedom Eccentric Mass Dynamic Vibration Absorber

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Abstract*: Design & development of experimental setup was been made or fabricated and was use to cancel out the resonating frequency and to lower the amplitude vibration which is called as dynamic vibration absorber (DVA). In this a system of spring-mass-damper was fabricated as a set up. In this setup, a vibratory model was been developed for the eccentric mass as an rotational unbalance load to develop some vibratory motion for the two degrees of freedom system (2 DOF). In this project, a prototype of vibratory physical setup was developed and compared to experimental findings and measurements of observations using the physical model.*

Keywords: Dynamic Vibration Absorber(DVA), 2DOF,Natural Frequency, Resonance.

I. INTRODUCTION

The vibration absorber is a crucial component used in the majority of vibrating machinery. Under different external excitations, the machine and its parts may experience unwanted vibrations while operating. The dynamic vibration absorber is required to prevent resonance of the machinery, failure due to machine breakdown, and major damages brought on by dangerous, unsafe vibrations. These passive dynamic vibration absorber parts work on the theory of adding a spring and mass whose natural frequency is adjusted to the system's resonant excitation frequency.

The original system remains unaffected since it transmits all of the resonance energy of the system to the dynamic vibration absorber. So as to demonstrate this phenomenon in action for the Introduction to Engineering Vibrations class, the project focuses on building the ideal model of the vertical 2-DOF spring mass- damper system with a DVA, which is not readily accessible.

II. EXISTING MODELS

The Dynamic Vibration Absorber (DVA) is a model which represents the damping in vibrating structure. The model shows the principle of DVA by absorbing vibrations from the main system and preventing it from hazardous vibrations. This model deals with the study of tuning the natural frequency of the damper to the natural frequency of the main system or primary system. By this frequency of the main system get reduced or absorbed by resonating out the frequency of main system.

The acceleration of the main system is determined with the help of accelerometer to validate the difference before damping and after damping. MATLAB Code is also produced to demonstrate the comparison between theoretical and practical observations using plotted graphs.

1.1 Objectives

- The objectives of the project are as follows:
- Mathematical model development for a given 2DOF system.
- Determination of natural frequency of the system.
- Fabrication of the set up.

- Plot a MATLAB code of theoretical model displacement amplitude response with respect to excitation frequency.

III. LITERATURE SURVEY

[1] Design and Analysis of Tune Mass Damper System by Abdul Bari Sayyed, Ganesh Sonar, Kunal Suryawanshi, Mohammad Gaus Shaikh, Satyam Taware (10, October-2020).
In this research paper, a vibratory 2DOF system was developed where primary system as well as secondary system vibrates or reciprocates vertically in between two steel rods. Both the systems were attached with the help of springs An accelerometer was use to measeure the acceleration (ADXL335) of the system before damping and after damping. And an Arduino Uno was use to load the code to determine acceleration and record the acceleration values.

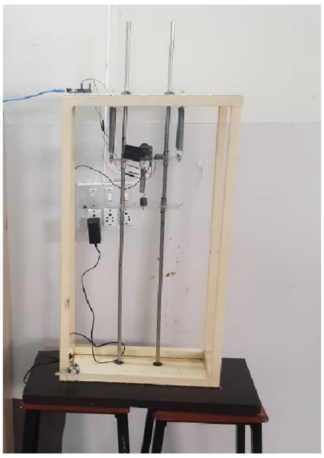
[2] Eccentric Mass Dynamic Vibration Absorber by Timothy G. Southerton, Brian T. Grosso, Kyle J. Lasher (2014)
This research paper gives the idea of development of physical model of spring-mass-damper in which the primary system vibrates at different amplitudes and frequencies. The theoretical values were compared with practical values to conclude the accuracy of the physical model. A MATLAB code was been developed to show the comparison between the theoretical and experimental values.

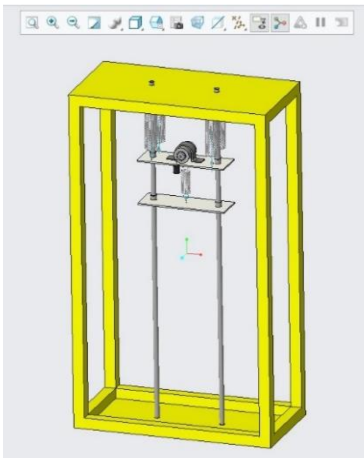
IV. METHODOLOGY

Assumptions:

- System should be 2 degree of freedom with 1 degree of motion
- Stationary rotation of the motor.
- Setup frame is fixed to a support and does not vibrate.
- No over elongation of springs.
- Avoid the effect of gravity on the eccentric load.
- No horizontal movement, pitch, roll in the platform.
- Motion is undamped.
- Motion is carried out without friction.
- Linear operating range of springs.

This model represents the actual vibrations existing into real machineries, structures, models, etc. by designing and developing a prototype experimental model.An eccentric mass or load is attached to the main system, which is made to vibrate by the rotating element called DC Motor with some eccentricity for the eccentric mass.Now the vibrations are generated into the main system, we have achieved a vibrating behavior similar to the real-life vibrations occurring in machineries and structures. These vibrations can cause harm to the main system and sometimes in real life examples it may lead to a hazardous destruction.





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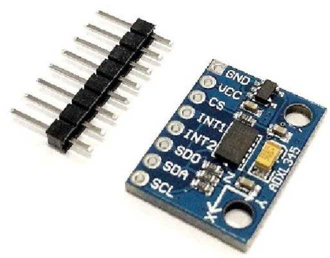
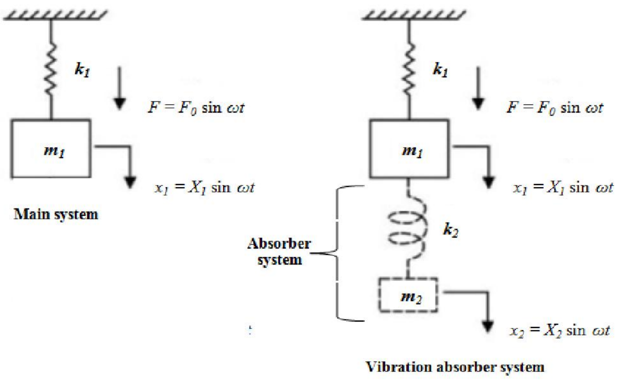
To prevent this, an auxiliary spring mass system is introduced to the main or primary system. The mass and stiffness of the auxiliary system is adjusted so as to match with the natural frequency of the main system which will cancel out the resonating frequency and provide a smaller number of vibrations to the main system.

In real-life scenarios, the vibrations occurring in machineries or structures are in various forms, so to measure this small and rapid vibrations as well as large vibrations we have use the combination of Accelerometer and Arduino Uno. This accelerometer is connected to the vibrating structure and gives amount vibration or acceleration values with respect to time. Arduino also collects and processes the data to give us the desired output using live co-ordinate values and live plotting graphs with the help of tools like serial monitor and serial plotter in Arduino interface or IDE.



The MATLAB code is generated to produce the graphs of theoretical and practical natural frequencies before and after damping for the comparison.

V. MATHEMATICAL MODELLING



Primary system spring stiffness: -

$F = K \times x$

For 1st mass m1,

Weight of mass = 108gm

F = 108gm

In Newton, $F = \frac{108}{1000} \times 9.81$ N

F = 1.05948N

$\frac{Deflection\ of\ spring}{Change\ in\ length\ of\ spring}$, x = 2.55cm = 0.0255m

$F = K \times x$

$1.05948 = K \times 0.0255$

K11 = 41.54 N/m

Similarly, for 2nd mass m2= 108gm & x=2.6cm

Spring stiffness K, K12 = $\frac{1.0594}{0.026}$

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K12 = 40.74 N/m

Average - $K1 = \frac{(K11+K12)}{2} = \frac{(41.54 + 40.74)}{2}$

$K1 = 41.14 N/m$

Equivalent spring stiffness:-

As 4 springs are in parallel,

K1 equivalent = 4 × K1

K1 equivalent = 4 × 41.14

K1 equivalent = 164.572N/m

Secondary system spring stiffness: -

F = K × x

For mass m1, F = 108 gm $F = \frac{108}{1000} \times 9.81$ N

F = 1.0594 N

Change in length for m1, x = 3.7 cm = 0.037 m

Stiffness for m1, $K21 = \frac{1.0594}{0.036}$

K21 = 28.63 N/m

For mass m2, F = 63 gm $F = \frac{63}{1000} \times 9.81$ N

F = 0.6174 N

Change in length for m2, x = 2.1 cm x = 0.021 m

Stiffness for m2, $K22 = \frac{0.6174}{0.021}$

K22 = 29.4 N/m

Average:- $K2 = \frac{(K21+K22)}{2}$

K2 = 29.015 N/m

Now,

Energy balance equation, $\frac{K1}{m1} = \frac{K2}{m2}$

$$\frac{164.572}{282} = \frac{29.015}{m2}$$

m2= 49.71 gm

VI. RESULT AND CONCLUSIONS

The vibrations formed in the main system before and after damping shows the difference that the acceleration in the main system is reduced after damping.

The Accelerometer gives the following results in the form of graphs with the help of serial plotter.

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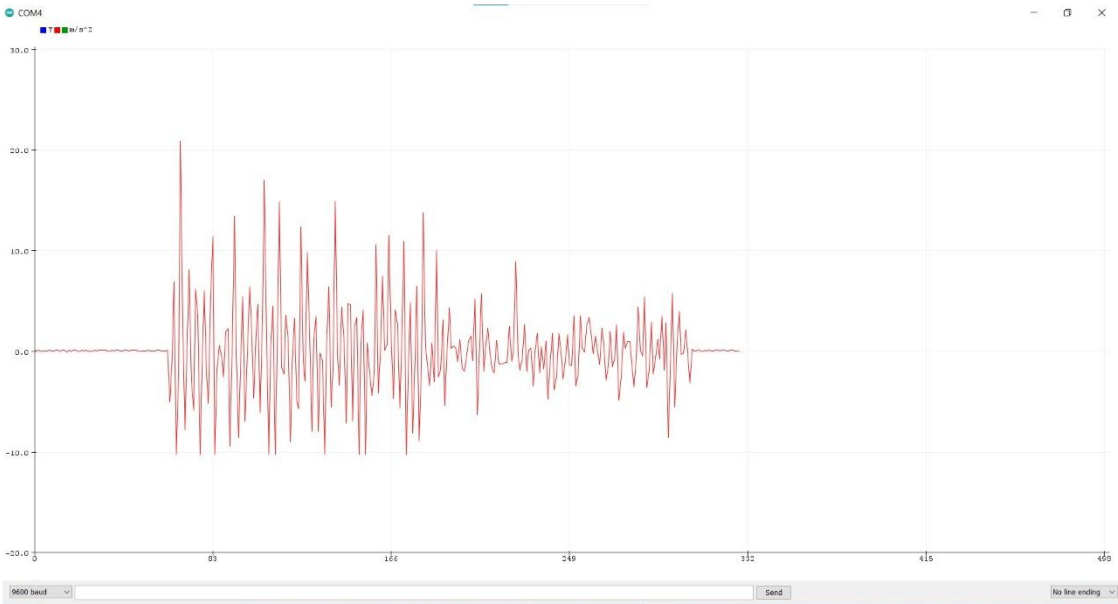
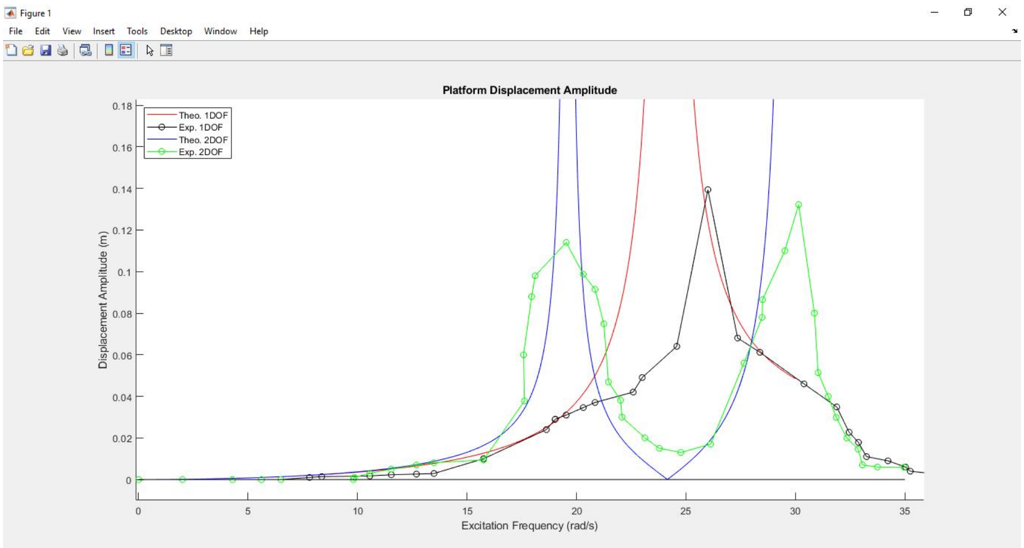


The vibrations of the primary system can be damped and absorbed by adding secondary system to it. The following graph shows the difference between the amplitudes of primary and secondary system by comparing theoretical and practical values. And by this experiment we conclude that when the auxiliary system is connected to the main system the vibrations of the primary system is reduced.



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