



Magnetically Tuned Mass Damper

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Abstract - Any elastic body such as spring, shaft or beam when displaced from its equilibrium position by application of external forces and then released commences cyclic motion known as vibrations. A TMD (Tuned Mass Damper) is a device consisting of a mass, a spring and a damper that is attached to a structure in order to reduce the dynamic response of the structure. The frequency of damper is tuned to a particular structural frequency so that when that frequency is excited, the damper will resonate out of phase with the structural motion. Vibration suppression with Tuned Mass Damper (TMD) is effective only for certain natural frequency. The performance evaluation of proposed MTMD in vibration suppression of dynamic vibration absorber is carried out using experimental setup. The experimental set up is designed to perform experimental test to validate the simulation results. The purpose of this study is designing and modeling of Magnetically Tuned Mass Damper (MTMD). Exploring the areas where its application can be used. Designing application for suspension system of the car.

Keywords— Tuned Mass Damper, Magnetically Tuned Mass Damper, Dynamic Response, Suspension system.

1. INTRODUCTION

1.1. INTRODUCTION

Magnetically tuned mass damper is a passive type of damper used in civil structures to damp the vibrations. MTMD works on the principle of formation of eddy currents. Eddy currents are generated when a moving conductor intersects a stationary magnetic field, or vice versa. The relative motion between the conductor and the magnetic field induces the circulation of the eddy current within the conductor. These circulating eddy currents induce their own magnetic field with the opposite polarity of the applied field that causes a resistive force. This resistive force suppresses the vibrations of the structure. A traditional tuned mass damper system is effective only for tuned natural frequency. MTMD works also on frequencies other than natural frequency of the structure. One of the most useful properties of an eddy current damper is that it forms a means of removing energy from the system without ever contacting the structure. This means that unlike other methods of damping, such as constrained layer damping, the dynamic response and material properties are unaffected by its addition into the system.

1.2. Literature Review.

Jae-Sung Bae [1] have proposed an effective method to suppress the vibration of a large and heavy beam structure with a minimum increase in mass or volume of material. They proposed method in which they apply relatively light-weight TMD to attenuate the vibration of a large beam structure and increase its performance by applying eddy current damping to a TMD. The results of experiment show that the present method is simple and effective in suppressing the vibration of a large beam structure without a substantial weight increase. Junda Chen [2] they have used an eddy current tuned mass damper (ECTMD) to control the vibration of a cantilever beam. The robustness of the ECTMD against frequency detuning is experimentally studied in cases of both free vibration and forced vibration. For purposes of comparison with the ECTMD, the robustness of a tuned mass damper (TMD) is also studied. Rahul Sharma [3] the goal of their study was to measure the damping of the beam as a function of the gap between the copper conducting plate and the surface of the permanent magnet. The density of the eddy current is directly related to velocity of conductor in magnetic field. Jaehyeong Lee [4] proposed an effective method to suppress the vibration of cantilever plates like the solar panels of a satellite. Magnetically Tuned Mass Damper (MTMD) is a Tuned Mass Damper (TMD) with Eddy Current Damping (ECD). Furthermore, they used magnetically tuned mass dampers to suppress the vibration of the plate.

Wang Zhihao [5] have discussed the design, analysis, manufacture and testing of a large-scale horizontal TMD based on ECD. First, the theoretical model of ECD was formulated, then one large-scale horizontal TMD using ECD is constructed, and finally performance tests of the TMD are conducted. Moreover, it is demonstrated that the damping ratio in the proposed TMD can be easily adjusted by varying the air gap between permanent magnets and conductive plates.

1.3. Problem Statement.

Although TMD is known as one of the effective methods for suppressing structural vibrations by mounting an additive mass on primary structure it has a couple of disadvantages for example it can perfectly suppress the vibrations in particular range of frequency but it may encourage vibrations in other range of frequency. Besides if the primary structure has structural variations such as change in mass or shape then effectiveness of TMD may decrease considerably.

2. Experimental Setup

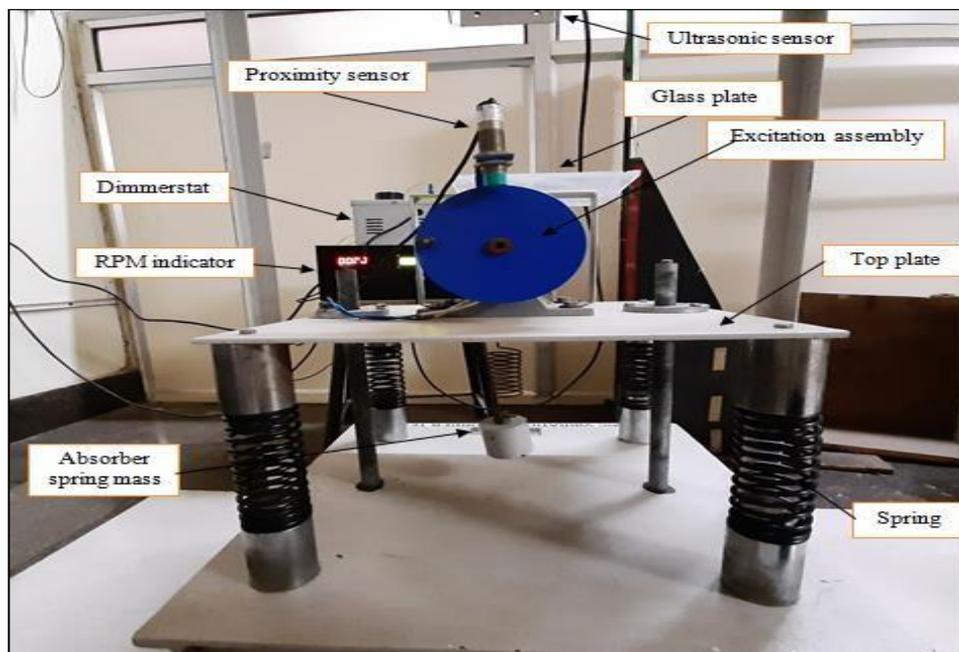


Fig -1: Experimental setup.

- i. The apparatus consists of four compression springs along with a top plate.
- ii. On which exciter assembly is mounted, in order to create vibration in plate.
- iii. A proximity sensor is fitted on motor for RPM indication.
- iv. A glass plate is fitted parallel to the top plate, in order to measure vibration in the top plate.
- v. An ultrasonic sensor is fitted perfectly above the glass plate, so that it senses the movement of the glass plate and hence the top plate.
- vi. A dimmerstat is used to control the speed of exciter assembly.
- vii. RPM indicator & Digital displacement indicator is used to show speed of motor and displacement of top plate respectively.

3. Experimental Procedure:-

Selection of speeds for reading.

- i. Check that dimmerstat is on zero.
 - ii. Switch ON panel.
 - iii. Now increase the speed of exciter with very small increment of dimmerstat knob.
 - iv. During this observe the displacement of top plate in digital displacement indicator.
 - v. With increase in exciter speed, displacement first increases up to resonance condition, then it decreases up to zero.
 - vi. Note down the RPM at which the maximum displacement of top plate occurs.
 - vii. Set dimmerstat knob at zero position.
 - viii. Switch off panel.
- In order to check effectivity of MTMD over TMD, from above procedure we select three speeds at which reading is to be taken. i.e. resonance condition speed, one above the resonance condition speed and one below the resonance condition speed.

The speeds are:-

1. 290 RPM (below the resonance condition)
2. 312 RPM (resonance condition)
3. 330 RPM (above the resonance condition)

Part B :-Analysis with TMD

- i. Fix absorber mass of 0.8 Kg found from calculation, at the spring which is fixed at the bottom of plate precisely.
- ii. Check that dimmerstat is on zero.
- iii. Switch ON panel.
- iv. Run the experimental setup at 3 predefined speeds.
- v. Simultaneously, note the displacement reading in displacement indicator at those three predefined speeds.
- vi. Set dimmerstat knob at zero position.
- vii. Switch off panel.

3. RESULTS**Parametric Study of TMD and MTMD:-**

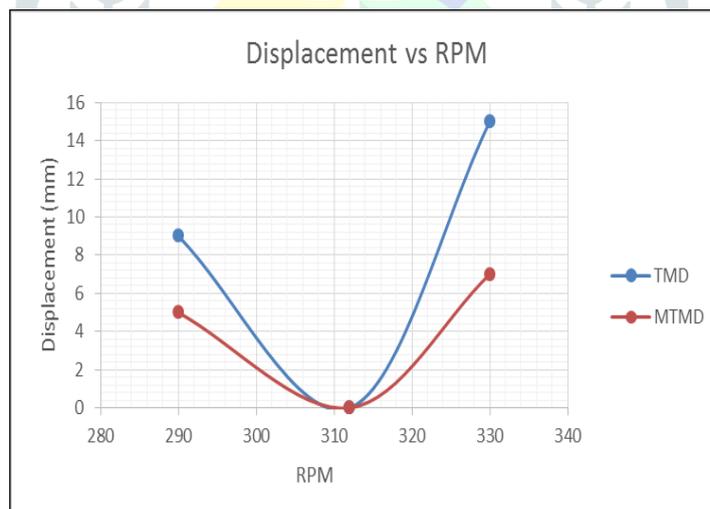
- The resonant frequency or natural frequency of the setup was at 312 rpm at which maximum displacement occurs for the plate.
- When TMD is attached to the setup it effectively damps the vibration of the plate to zero at 312 rpm but still gives some amount of displacement at 290 rpm and 330 rpm which is below and above resonant frequency.
- However, MTMD when attached to setup, because of the reaction between neodymium magnet and copper plate setup gives damping wider band of 290 to 330 rpm including 312 rpm. With effective damping and zero displacement of plate.

Various readings of “displacement” of top plate are as follows:-

Type	RPM	290	312	330
TMD		9	0	15
MTMD		5	0	7

Table 6.1.1: Displacement reading of top plate

*Here MTMD reading taken at optimum gap and thickness.



4. Application

The Eddy Current Damper or MTMD can be used in various sectors including :-

- Automobile Sector.
- Aeronautics (Rocket and Planes).
- Ship Building.
- Sky scrappers.
- Heavy Bridge Construction etc.

Eddy Current damping in Automobile sector particularly in suspension system

4.1. Construction :-

The Eddy Current suspension system consist of following parts:-

- Permanent Magnet (Neodium magnet) :- We have used Cylindrical Circular neodium magnet in hollow cylinder.
- Stator Winding :- The copper coil stator winding is attached on cylinder containing neodium magnet in order to provide electromotive force.
- Air gap cylinder housing :- There is air gap between magnet and the winding in order for generating eddy current.
- Cylinder:- These is the outer casing for which enclosed entire structure.

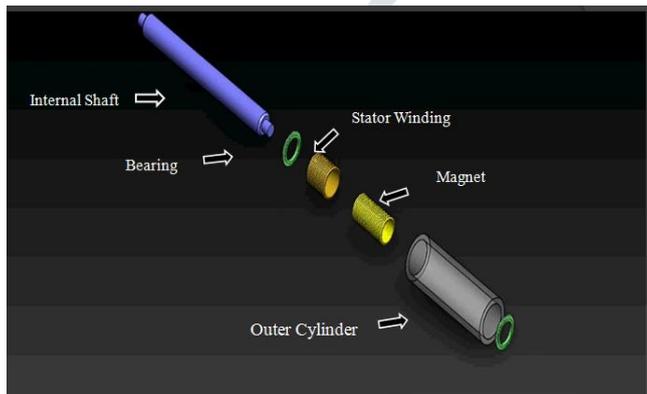


Fig.-3 : Parts of Suspension Cylinder

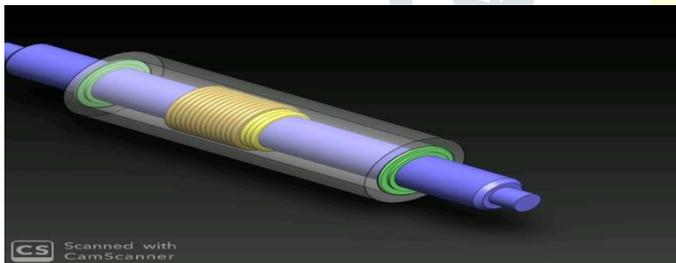


Fig.-2: Graph: displacement vs. rpm.

Fig.-4 : Assembly of Suspension Cylinder.

4.2. Working Of Suspension System

- When there is bump or irregularity in road which activates suspension system in order to reduce the effect of bump.
- The vibrations are taken to the cylinder having magnet on it. Thus cylinder reciprocates linearly.
- As vehicle oscillates relative displacement takes place between permanent magnet and stator coil.
- These stator coil cuts the magnetic line and generates Eddy current, thus the damping process takes place.
- This woking takes place inside the outer casing.

4.3. Advantages

Compared to Hydraulic Suspension system advantages of ECD Suspension System are:

- 1) increased efficiency
- 2) improved dynamic behavior
- 3) stability improvement
- 4) accurate force control

5.CONCLUSIONS

- TMD gives maximum damping only for the tuning frequency and is ineffective in damping the vibration in other range of frequencies MTMD overcomes the disadvantage of TMD and gives damping in other frequencies with the tuning frequency increasing the bandwidth for different values. The damping by MTMD is 2 times that of TMD.

6.REFERENCES

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