EXPERIMENTAL EVALUATION AND ANALYSIS OF SEMI ACTIVE PARTICLE BASED DAMPING SYSTEM USING MAGNETIC FIELD.

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Abstract - *When planning to design a suspension system for an automobile it involves clear examination about the tires, linkages, springs (dampers) and other parts that are connected with the tire and the vehicle itself. In today's automobile industry, more concentration is on how comfortable the vehicle drives and by all means, its suspension system. The concept of structural control containing both passive and active control systems have been developing in consent. A semi-active control system is a compromise between passive and active control systems which has been developed recently. A semi-active control system keeps the reliability of passive control systems while taking advantage of the variable parameter characteristics of an active control system. In this report, the effect of electric flux, size of magnetic particles, materials of piston with respect to the amplitude of vibrations is studied for simply supported beam in which a magnetic particle bed is utilized to dissipate the energy of a vibrating piston. The system is magnetized by a magnetic field generated by supplying an electric current to an electromagnetic coil. Semi-active control is obtained by changing the electric current supplied to the coil. From the analysis, it is observed that the performance of semi active particle based damping controlled by magnetic field is dependent on the various parameters such as materials of the particles, size of particles, material of piston and supplied current. The damping efficiency of the system increases as the magnetization of the piston and particles increases up to saturation level. This system can be effective in aerospace, automobile and structural engineering applications, particularly in severe environments.*

Key Words: **Semi active control, Electric flux, Magnetic field, Vibration amplitude, FFT analyser, frequency response analysis.**

1. INTRODUCTION

Damping systems are classified into three categories namely passive, semi-active and active suspensions [9]. Passive, active and semi-active vibration control methods are used to provide external damping for aerospace, automotive and civil engineering applications. Passive systems use viscous fluids viscoelastic materials or tuned masses as dampers to dissipate energy without the use of actuators and external power supply. However, such systems are most effective only in a narrow Frequency range. Active damping systems can produce desired response characteristics for a variety of disturbances by using actuators to provide an active force to the vibrating structure. However, active systems are often limited in their use because their actuators require a large external source of power. A semi-active damping system addresses the limitations of the passive and the active system by integrating tunable control into a passive device by replacing force actuators with continually adjustable control elements which are capable of modifying a dampers energy dissipation rate in response to excitation conditions. Therefore, semi-active devices are also referred to as variable-rate or adaptive-passive dampers. This damping method is attractive because it requires a significantly lower amount of external power supply, as compared to the active system.

1.1 Problem Definition

The operation of any mechanical system will always produce some vibration so it is necessary to minimize the vibrations, because while it is undesirable, vibrations are unavoidable. The result of excess vibration can vary from annoying disturbance to a disastrous failure. All automobile vehicles, aerospace vehicles and industrial machineries must generate some vibration. These vibrations may just be an indicator of some problem with a mechanism, or it may be a cause of other problems. Viscoelastic damping is one of the most common methods of damping. However, the damping properties of viscoelastic materials are highly dependent on various parameters including strain rate, aging, temperature and pressure. At extremely low and high temperatures viscoelastic material properties may get changed. In such damping systems the damping properties are precisely decreases. In short, the performance of viscoelastic damper is affected in cryogenic environment. Therefore viscoelastic damper cannot be used at very low or high temperature and pressure. This problem can be avoided by using semi active particle based damping system.

It is proposed to analyse the performance of a semi active particle based damper controlled by magnetic field and to study the effect of various parameters such as effects of flux, material of piston and size of particles.

2. EXPERIMENTAL ANALYSIS OF A PARTICLE BASED DAMPING SYSTEM

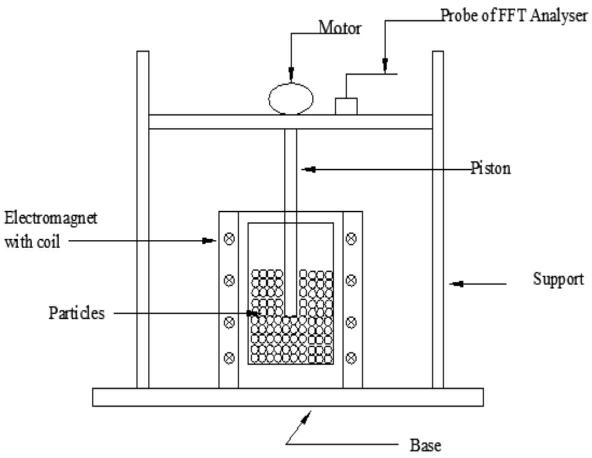


Fig -1: Experimental setup

The experimental setup consists of-

1. An oscillating piston to transfer energy from a vibrating medium to the damping medium. It is made from either steel (carbon steel) to produce a magnetic piston or aluminium to produce a non-magnetic one.

2. Magnetic particles (chrome steel) of different sizes (1 and 2 mm diameter) to dissipate the vibration energy and serve as a damping medium, and

3. An electromagnetic coil to generate a magnetic field of desired strength.

2.1 Procedure to obtain required results

1. Assemble the entire setup.

2. Connect the damper unit consisting of piston, cylinder filled with particles and an electromagnetic coil around the cylinder to the system.

3. An acceleration sensor with its magnetic probe is placed on the motor base frame. The probe is mounted on the frame near the motor because vibrations are more at that point.

4. A motor is started and readings are taken by varying current (0 – 1.2A) supplied to the coil.

5. Recorded the amplitude of oscillation of a damper having the magnetic piston (steel) and non magnetic (aluminum) piston with 1mm and 2mm diameter particles with the help of FFT analyzer.

Case 1: Effect of flux with steel (Magnetic) piston and particles of 1 mm size.

For current 0.0 A

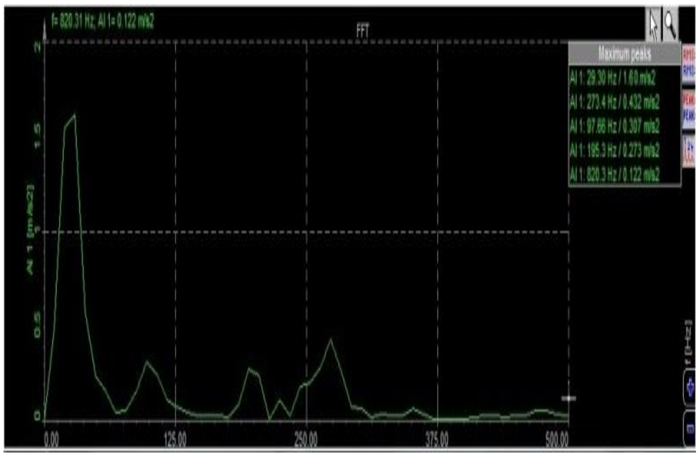


Fig 2: Frequency Response plot for 0.0A current

For current 0.2 A

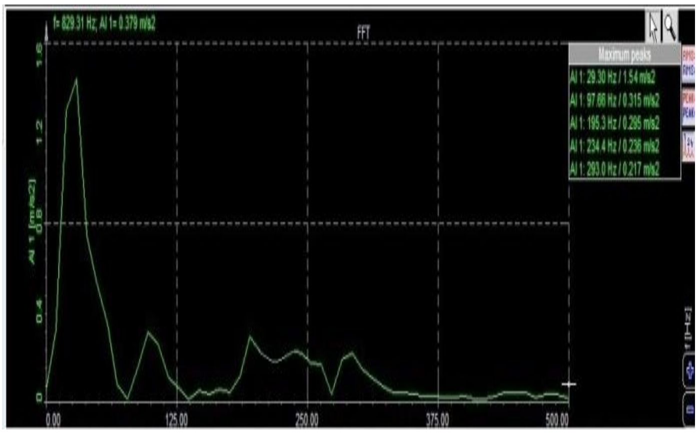


Fig 3: Frequency Response plot for 0.2A current

For current 0.4 A

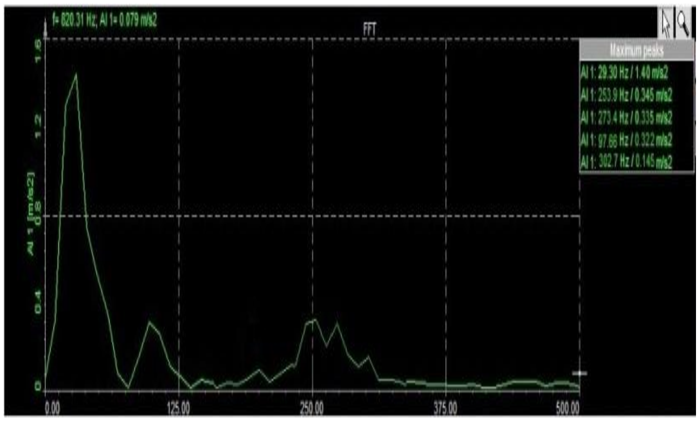


Fig 4: Frequency Response plot for 0.4A current

For current 0.6 A

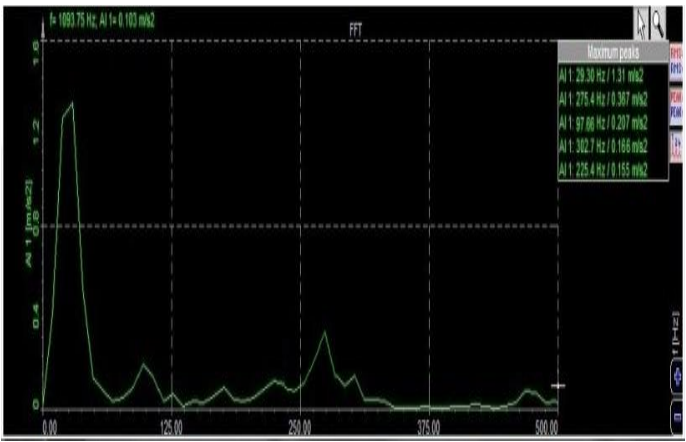


Fig 5: Frequency Response plot for 0.6A current

For current 0.8 A

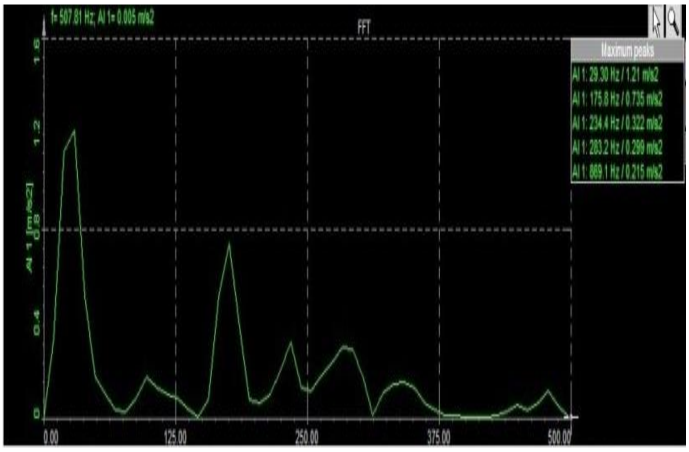


Fig 6: Frequency Response plot for 0.8A current

For current 1.0 A

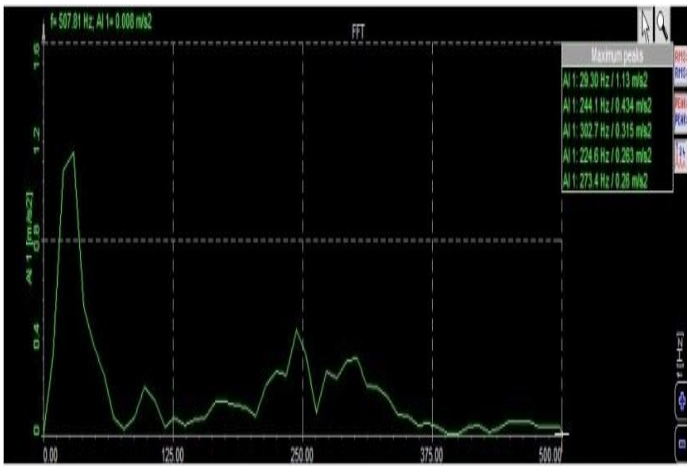


Fig 7: Frequency Response plot for 1.0A current

For current 1.2 A

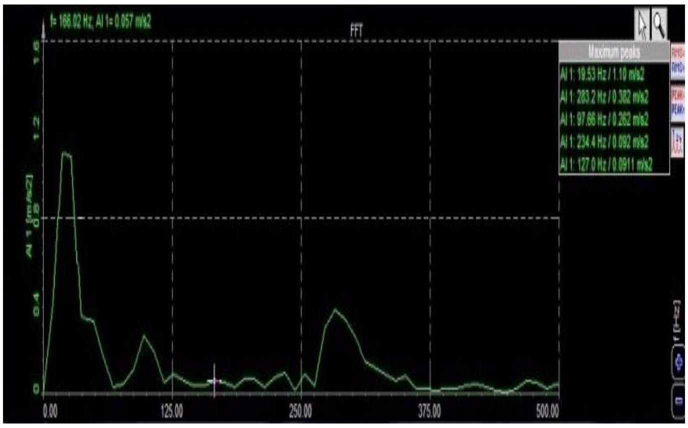


Fig 8: Frequency Response plot for 1.2A current

Similarly following cases are analysed,

Case 2: Effect of flux with steel (Magnetic) piston and particles of 2 mm size.

Case 3: Effect of flux with Aluminium (Non magnetic) piston and particles of 1 mm size.

Case 4: Effect of flux with Aluminium (Non magnetic) piston and particles of 2 mm size.

3. FINITE ELEMENT ANALYSIS

3.1 Modal analysis

It is used to determine the natural frequencies and mode shapes of the structure. The natural frequencies and mode shapes are important in the design of a structure for dynamic loading conditions. A modal analysis is a technique used to determine the vibration characteristics of structures.

Table -1: Different modes and corresponding frequencies

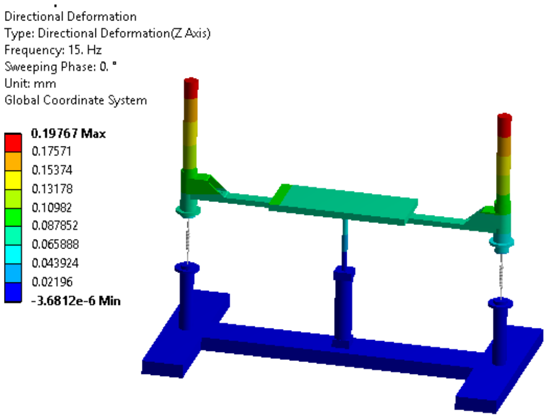
Modes	Frequency (Hz)
1	11.794
2	14.694
3	24.237
4	47.365
5	61.65
6	62.291
7	99.086
8	130.9
9	199.72
10	248.7

3.2 Frequency Response Analysis

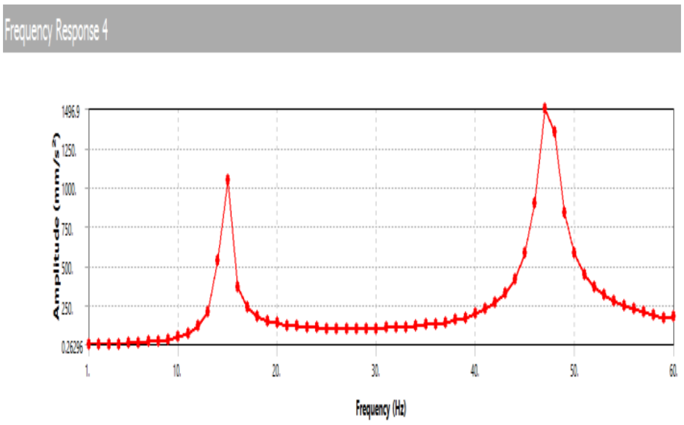
Case 1- Without Flux:

Piston Material- Steel

Variation of Displacement:



Acceleration v/s frequency



Displacement v/s Frequency

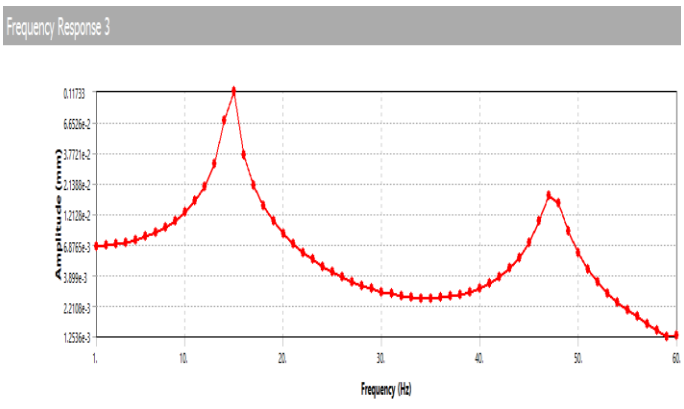
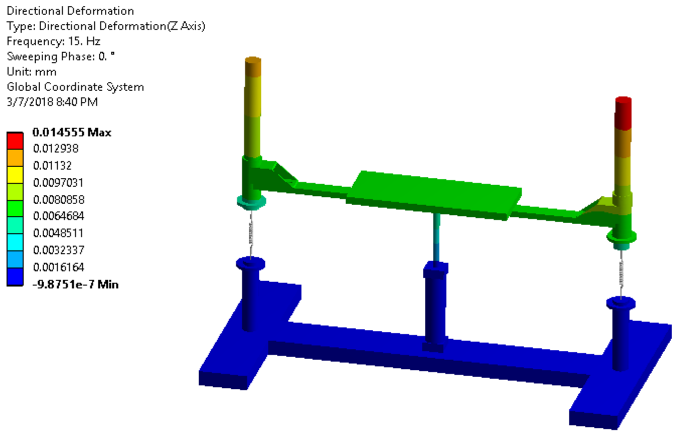


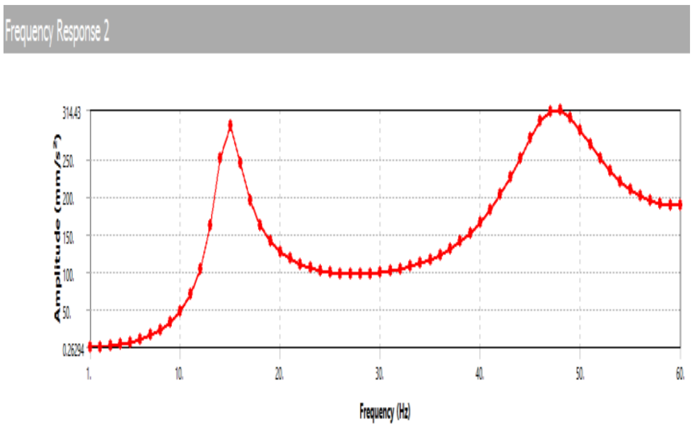
Fig 9: Variation of amplitude without flux and steel as piston material.

Case 2- With Flux
Piston Material – Steel

Variation of Displacement:



Acceleration v/s frequency



Displacement v/s frequency

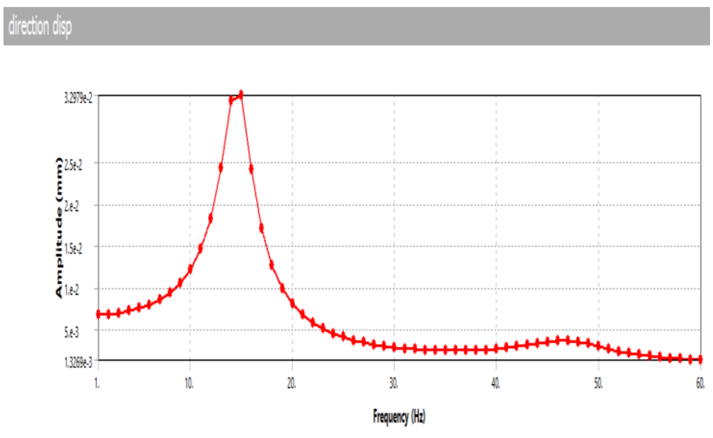


Figure 10: Variation of amplitude with flux and steel as piston material.

Similarly frequency response analysis has been carried out by considering with and without flux conditions for a non magnetic piston.

4. RESULTS AND DISCUSSION

4.1 Effect of flux with steel (Magnetic) piston and particles of 1 and 2 mm size.

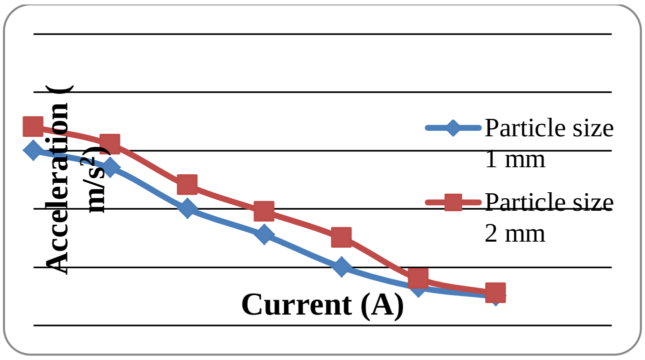


Fig 11: Combined effect of size of particles on damper with steel (magnetic) piston.

4.2 Effect of flux with Aluminum (non-magnetic) piston and particles of 1 and 2 mm size.

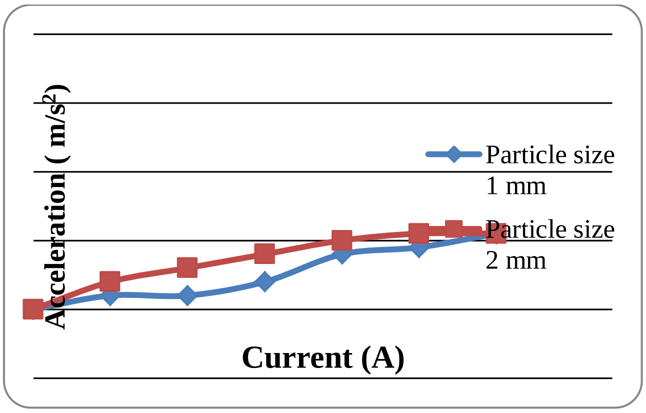


Fig 12: Combined effect of size of particles on damper with aluminum (non magnetic) piston

4.3 Result of frequency response analysis using FEA

Table -2: Result of frequency response analysis using FEA

Sr. NO.	Condition	Material of piston	Acceleration (m/s²)	Displacement (mm)
1	Without flux	steel	1.496	0.1173
2	Without flux	aluminum	1.413	0.2129
3	With flux	steel	0.3144	0.033
4	With flux	aluminum	1.815	0.433

5. COMPARISON BETWEEN EXPERIMENTAL AND FINITE ELEMENT ANALYSIS RESULTS

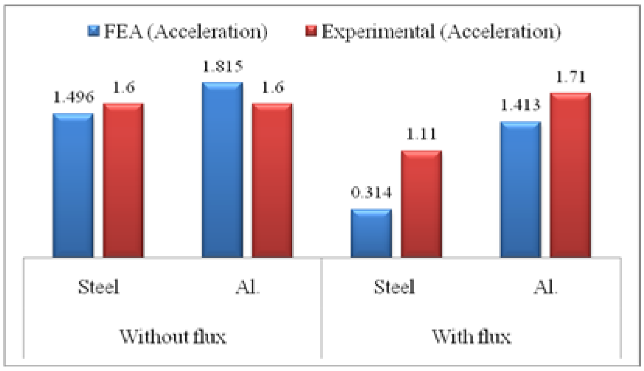


Figure 13: Comparison between FEA and Experimental results.

6. CONCLUSIONS

The performance of a semi active particle based damping system, using a dry magnetic particle bed as a damping medium to absorb and dissipate the energy of a vibrating piston is analyzed. The damping efficiency is achieved by controlling the electric current supplied to an electromagnetic coil to generate a magnetic field. From the analysis it is concluded that

1. In case of a magnetic (steel) piston, the magnetization of both particles and piston can enhance the damping efficiency until the magnetization saturates. It shows that as current goes on increasing acceleration goes on decreasing. Thus we get variable damping effect with the help of semi active particle based damper controlled by magnetic field.

2. On the other hand, for the case with a non- magnetic (Aluminum) piston, the damping system achieves the highest efficiency when particles are not magnetized, and the damping efficiency decreases with increasing magnetization.

3. Also the effect of particle size on the damping is studied. It is observed that for 2 mm particle size, the damping is precisely lower when compared with 1 mm particle size.

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