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Effect of Ball Size on Performance of Particle Damper

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Abstract: The study of particle damping involves the understanding of the various forces and mechanisms that cause energy to be lost from vibrating systems, leading to the reduction of their amplitudes over time. The cantilever beam is used for experimentation. FFT analyzer is used to find the response parameters. The readings are taken with varying cavity dimensions, size of ball, packing ratio and ball material. The response parameters in the form of acceleration are noted by varying one experimental parameter. From the experimentation it is found that 5 mm ball with sand material is effective for the applied experimental set-up.
Keywords: Transient Vibration, Particle damping, cantilever beam, Ball size, single-degree-of-freedom.

I. INTRODUCTION

Particle damping is a ubiquitous phenomenon that occurs in a wide range of physical systems, from mechanical vibrations and acoustic waves to biological and medical systems. It refers to the reduction of the amplitude or magnitude of an oscillating or vibrating system over time. In other words, it represents the gradual decay of the energy of a vibrating system.

Viscous damping occurs in systems where the motion of a particle generates resistance to its motion due to the presence of a fluid, such as air or water. This type of damping is often encountered in fluid dynamics, acoustics, and structural dynamics.

Radiation damping occurs when a vibrating system radiates energy in the form of sound, light, or electromagnetic waves. This type of damping is encountered in many physical systems, such as satellites and spacecraft, where energy is lost due to the emission of electromagnetic waves. Mathematically, particle damping can be modeled using differential equations, which describe the relationship between the velocity and acceleration of a vibrating system. The mathematical models used to describe damping in physical systems depend on the type of damping mechanism and the physical parameters of the system. In engineering and mechanical design, particle damping plays a crucial role in the design and analysis of structures, such as bridges and buildings, where the damping characteristics of a structure can significantly impact its stability and performance. Damping also plays a significant role in the design of control systems, where it can be used to stabilize a system or reduce the amplitude of its vibrations. In the field of vibrations, particle damping is used to study the behavior of vibrating systems, including the measurement of damping ratios and the identification of damping mechanisms. This information can then be used to design and optimize the performance of a system, by reducing the amount of energy lost to damping or increasing the efficiency of energy transfer. In medical and biological systems, particle damping plays an important role in the study of human movement and the mechanics of biological tissues, such as bones and muscles. The measurement of damping in biological tissues can provide important information about the mechanical properties of these tissues, which can be used to diagnose and treat diseases and injuries. In conclusion, particle damping is a fundamental and widespread phenomenon that plays a critical role in many physical systems. Whether it is used to design and optimize the performance of engineering and mechanical systems, or to study the mechanics of biological and medical systems, particle damping is a valuable tool for understanding and controlling the behavior of physical systems.

II. LITERATURE REVIEW

Xiao Has done dynamic analysis and experimental verification on extension housing for printed circuit board based on particle damping material. The study is based on to develop and design a new type of vibration reduction technology. By harmonic response analysis based on extension system they found that the peak frequency of extension system could be obtained and installation position of particle damper is determined. They have used ANSYS finite element software for 3D structure of solid element. They found that filling rate was 96% and best vibration reduction effect can reach 57.90%. They conclude that effect of vibration reduction is for less than the sensitive area of vibration transfer path .And this design method is completely suitable in harsh environment. [1] K.B. Sachidananda Studied the effect of powder particle size on vibration damping.

They have done experimental analysis by using dynamic mechanical analyzer (DMA). The surface morphology of the coating were studied using scanning electron microscope (SEM). In this analysis they found that the damping values were found to be increased with the increase in particle size in the measured strain range. The behavior was correlated with the microstructure investigated by SEM. [2] Louis has done modeling and testing particle damper used on beam. Analysis is done by DEM simulation software. These research shows overview on their advantages, modeling techniques, design consideration and experimental analysis. The emphasis is on particle dampers used on beam vibrating at frequencies between 10HZ and 1KHZ. [3] Hang ye Has done experimental study on damping effect of multiunit particle dampers which is applied to bracket structure. In this, Discrete element method (DEM) and experimental approach is used. With the help of fem ANSYS analysis is done. In this, The effect of additional structural quality, particle material and filling factor of particle damper on the damping effect is investigated by experiment. In this they found that, with the same filling factor, The tungsten carbide powder has the best damping effect. [4] Shinde Studied on particle damping technique for vibration suppression. With mathematical modeling experiments is done. This study reveals that passive damping technique by using damping particle like steel, plastic, granules etc. can suppress the vibration. [5] Meyer studied the damping behavior of particle dampers attached to a vibrating structure. In this, numerical and experimental analysis is done on vibrating structure. In this, a discrete element model is combined with a reduced finite element model and it can be analyzed for a wide frequency range. An efficient contact algorithm is used while a coupling with a FEM. [6] Marhadi Studied on particle impact damping for cantilevered beam with particle filled enclosure attached to its free end. They have done theoretical analysis and experimental analysis on cantilever beam. They also studied the effect of mass ratio, effect of number of particles and effect of particle material. Five materials have been tested: lead, steel, glass, tungsten carbide and sand. By experiment they conclude that particle impact damping (PID) must include size and number of particles as additional independent parameter. [7] Bai Studied on particle dynamic simulation of a piston based particle damper. They have proposed piston based particle damper geometry and investigated using experiments and particle dynamic simulation. They have done experimental setup on particle based thrust damper. The simulation results were compared and validated with experimental setup. Their results shows that high damping capacity can be achieved in piston based particle damper. The particle size effect was also investigated in this simulation. [8] Zheng Lu studied the performance of particle dampers under dynamic loads. They have done systematic investigation of the performance of particle dampers attached to primary system and multi degree of freedom under different dynamics loads. Discrete element method is used for analysis. This study investigated the performance of a vertical particle damper under free vibrations. [9] Zhang studied Damping Characteristics of Cantilever Beam with Obstacle Grid Particle Dampers. They conduct Experimental setup and simulated studies. In this they uses discrete element Software (EDEM) to simulate and model the particle dampers with and without the obstacle gird. In this they found that with increase of excitation amplitude, damping effect of traditional particle damper is 10.7 dB, 7.1 dB, 4.6 dB and 2.9 dB, respectively. And conventional particle dampers reduce the level of vibration energy transfer and dissipation due to fluidization of particles. [10] Tobias studied Design of Particle Dampers for laser powder bed fusion. In this they found that manufactured particle dampers can significantly improve component damping. If designed incorrectly, the damping can be worsened. So they done a Experimental Methodology for that and conducted experiments. And they found positive effect of the particle damping in a frequency range from 500 to 30,000 HZ.[11]

III. EXPERIMENTAL SETUP

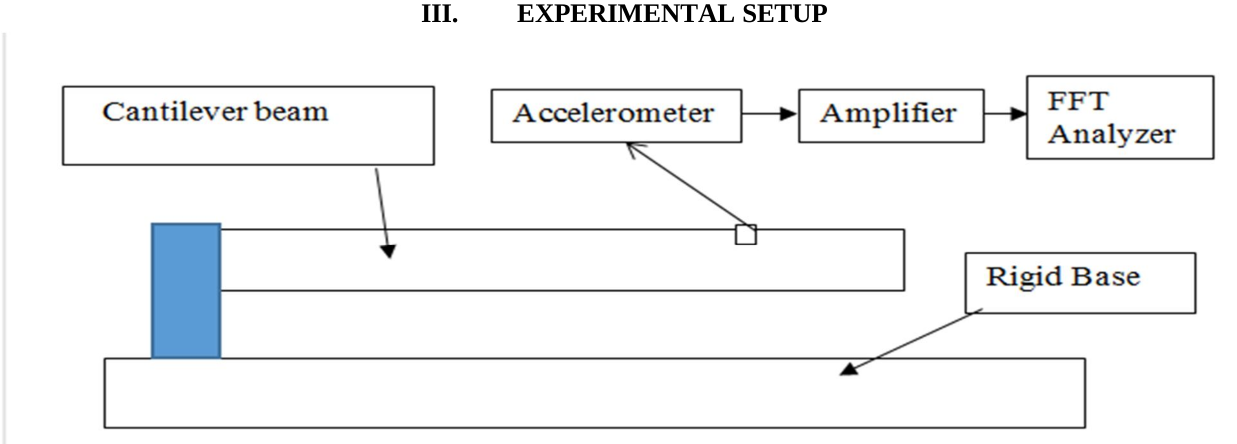

Fig.1 Experimental setup

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Fig.1, shows the experimental apparatus used in this study. The experimental apparatus consists of the primary structure, and acts as an equivalent single-degree-of-freedom system. The structure is like a cantilever beam. The particle damper consists of three cylindrical cavities. To investigate the effect of the cavity diameter and packing ratio, ball size and ball material on the damping efficiency. The cavities are partially filled with granular particles of the same size. Readings for acceleration are taken with the help of FFT analyzer for transient.

IV. EXPERIMENTATION

In this first case, we will try to find out the effect of ball size on the performance of damper. Total 12 experiments are carried out varying the remaining parameters. In this experimentation, the cavities used are with 24mm diameter with 37 mm height, 24mm diameter with 47 mm height and 32 mm diameter with 56 mm height. The first experiment is carried out with cavity 24mm diameters and height 37 mm With Packing ratio 25%. The ball size and ball material is varied to find the acceleration. The second experiment is carried out with cavity 24 mm diameters and height 37 mm With Packing ratio 50%. The ball size and ball material is varied to find the acceleration. The third experiment is carried out with cavity 24 mm diameters and height 37 mm With Packing ratio 75%. The ball size and ball material is varied to find the acceleration. The fourth experiment is carried out with cavity 24 mm diameters and height 37 mm With Packing ratio 100%. The ball size and ball material is varied to find the acceleration. The fifth experiment is carried out with cavity 24mm diameters and height 47 mm With Packing ratio 25%. The ball size and ball material is varied to find the acceleration. The sixth experiment is carried out with cavity 24mm diameters and height 47 mm With Packing ratio 50%. The ball size and ball material is varied to find the acceleration. The seventh experiment is carried out with cavity 24mm diameters and height 47 mm With Packing ratio 75%. The ball size and ball material is varied to find the acceleration. The eighth experiment is carried out with cavity 24mm diameters and height 47 mm With Packing ratio 100%. The ball size and ball material is varied to find the acceleration. The ninth experiment is carried out with cavity 32mm diameters and height 56 mm With Packing ratio 25%. The ball size and ball material is varied to find the acceleration. The tenth experiment is carried out with cavity 32mm diameters and height 56 mm With Packing ratio 50%. The ball size and ball material is varied to find the acceleration. The eleventh experiment is carried out with cavity 32mm diameters and height 56 mm With Packing ratio 75%. The ball size and ball material is varied to find the acceleration. The twelfth experiment is carried out with cavity 32mm diameters and height 56 mm With Packing ratio 100%. The ball size and ball material is varied to find the acceleration.

V. RESULTS

The results of all the experiments are given as bellow.

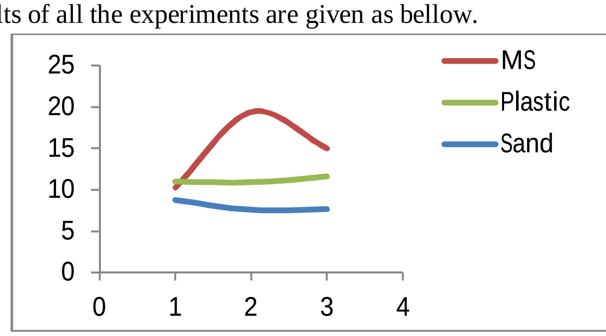

Fig.2

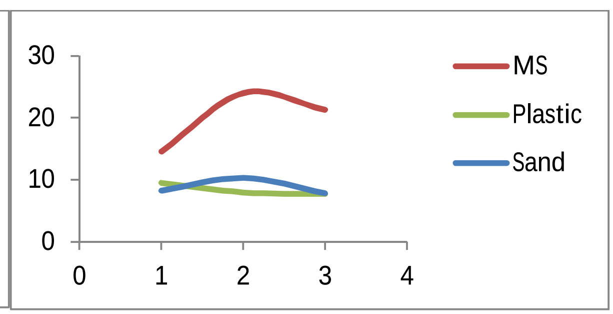

Fig.3

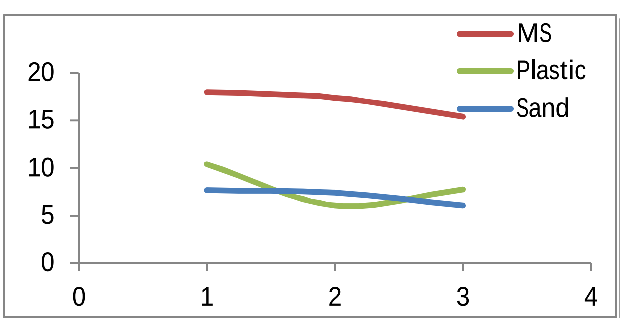

Fig.4

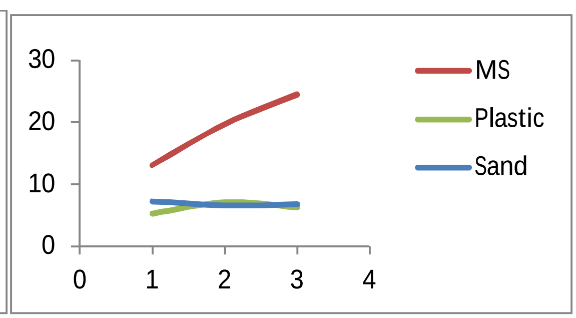

Fig.5

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In the first experiment, as shown in (Fig. 2) the maximum damping is found for sand material with ball size 5 mm. the minimum damping is found for mild steel material with ball size 5mm. In the second experiment, as shown in (Fig.3) the maximum damping is found for plastic material with ball size 6 mm. the minimum damping is found for mild steel material with ball size 5mm. In the third experiment, as shown in (Fig.4) the maximum damping is found for plastic material with ball size 5 mm. the minimum damping is found for mild steel material with ball size 4mm. In the fourth experiment, as shown in (Fig.5) the maximum damping is found for plastic material with ball size 4mm. the minimum damping is found for mild steel material with ball size 6mm.

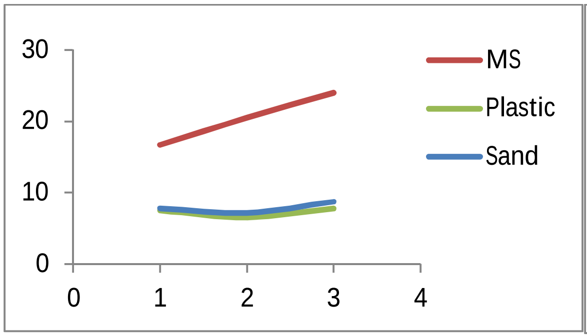

Fig.6

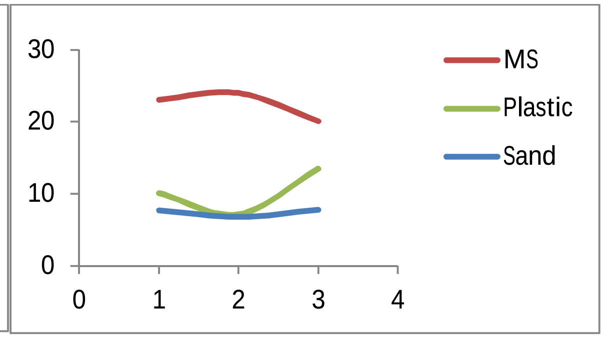

Fig.7

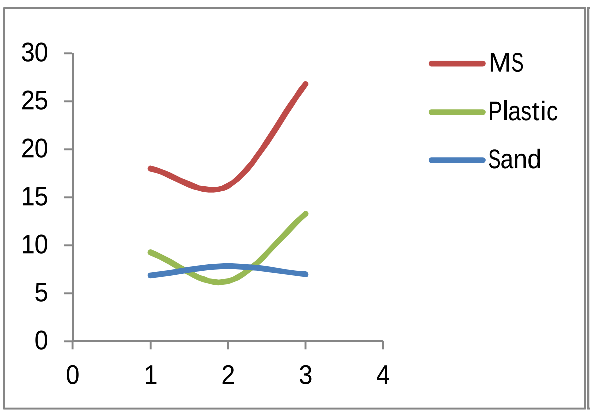

Fig.8

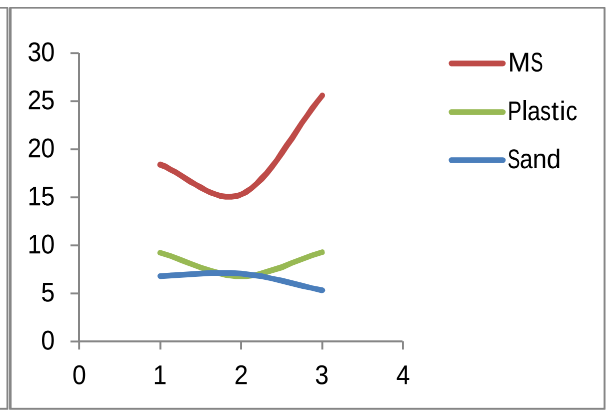

Fig.9

In the fifth experiment, as shown in (Fig.6) the maximum damping is found for plastic material with ball size 5mm. the minimum damping is found for mild steel material with ball size 6mm. In the sixth experiment, as shown in (Fig.7) the maximum damping is found for sand material with ball size 5mm. the minimum damping is found for mild steel material with ball size 5mm. In the seventh experiment, as shown in (Fig.8) the maximum damping is found for plastic material with ball size 5mm. the minimum damping is found for mild steel material with ball size 6mm. In the eighth experiment, as shown in (fig.9) the maximum damping is found for sand material with ball size 6mm. the minimum damping is found for mild steel material with ball size 6mm.

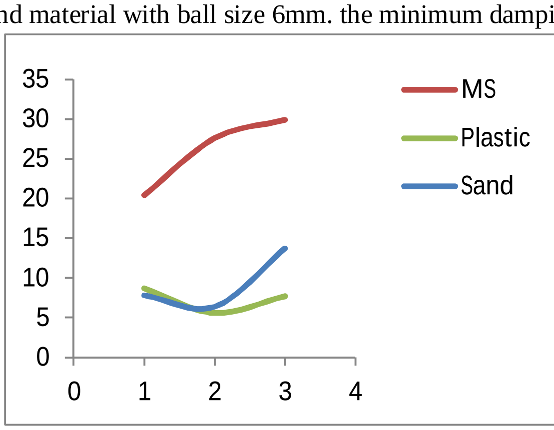

Fig.10

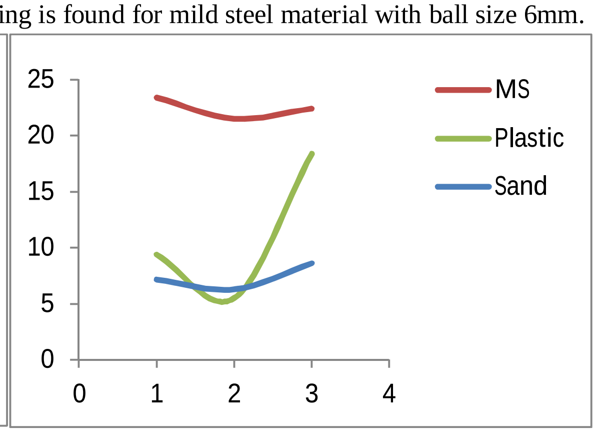

Fig.11

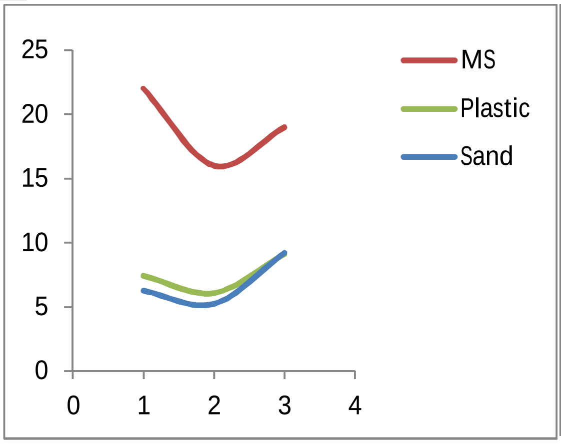

Fig.12

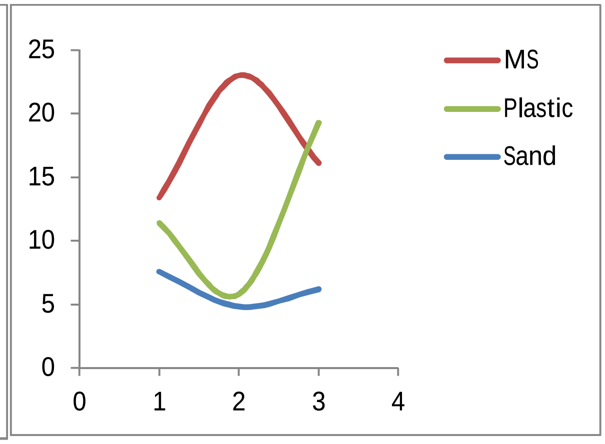

Fig.13

In the ninth experiment, as shown in (Fig.10) the maximum damping is found for plastic material with ball size 5mm. the minimum damping is found for mild steel material with ball size 6mm. In the tenth experiment, as shown in (Fig.11) the maximum damping is found for plastic material with ball size 5mm. the minimum damping is found for mild steel material with ball size 4mm. In the eleventh experiment, as shown in (Fig.12) the maximum damping is found for sand material with ball size 5mm. the minimum damping is found for mild steel material with ball size 4mm. In the twelfth experiment, as shown in (Fig.13) the maximum damping is found for sand material with ball size 5mm. the minimum damping is found for mild steel material with ball size 5mm.

VI. CONCLUSIONS

For cavity 24mm diameter and height 37 mm, packing ratio 25% for mild steel ball size 4 mm and for plastic and sand ball size of 5mm is found effective. For cavity 24mm diameter and height 37 mm, packing ratio 50% for mild steel ball size 4 mm and for plastic and sand ball size of 6 mm is found effective. For cavity 24 mm diameter and height 37 mm, packing ratio 75% for mild steel and sand ball size 6 mm and plastic ball size of 5 mm is found effective. For cavity 24 mm diameter and height 37 mm, packing ratio 100% for mild steel, plastic ball size of 4 mm and for sand ball size of 5 mm is found effective. For cavity 24 mm diameter and height 47 mm, packing ratio 25% for mild steel ball size of 4 mm and for plastic and sand ball size of 5 mm is found effective. For cavity 24 mm diameter and height 47 mm, packing ratio 50% for mild steel ball size of 6 mm and for plastic and sand ball size of 5 mm is found effective. For cavity 24 mm diameter and height 47 mm, packing ratio 75% for mild steel, plastic ball size of 5 mm and for sand ball size of 4 mm is found effective. For cavity 24 mm diameter and height 47 mm, packing ratio 100% for mild steel, plastic ball size of 5 mm and for sand ball size of 6 mm is found effective. For cavity 32 mm diameter and height 56 mm, packing ratio 25% for mild steel ball size of 4 mm and for plastic and sand ball size of 5 mm is found effective. For cavity 32 mm diameter and height 56 mm, packing ratio 50% for mild steel, plastic and sand ball size of 5 mm is found effective. For cavity 32 mm diameter and height 56 mm, packing ratio 75% for mild steel, plastic and sand ball size of 5 mm is found effective. For cavity 32 mm diameter and height 56 mm, packing ratio 100% for mild steel ball size of 4 mm and for plastic and sand ball size of 5 mm is found effective. From all this result we get For cavity 32 mm diameter and height 56 mm, packing ratio 100% for sand material with ball size of 5 mm is found most effective.

VII. ACKNOWLEDGMENT

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