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Experimental Investigation of Vibration Damping System Using Pendulum and Spring

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ABSTRACT

Vibration damping systems play a critical role in reducing unwanted oscillations in mechanical structures and systems. This paper presents a novel vibration damping system utilizing a pendulum and spring mechanism. The system combines the principles of dynamic resonance and energy dissipation to effectively attenuate vibrations. The pendulum acts as a passive energy absorber, oscillating in response to the external vibrations, while thes pring provides additional damping through its elastic restoring force. The interaction between the pendulum's motion and the spring's force creates a dual-stage damping effect, improving the system's overall efficiency in reducing vibration amplitudes. A theoretical model is develop dto analyze the performance of this hybrid damping system, considering factors such as spring constant, pendulum length, and damping coefficient. Here's the revised version of your statement. Experimental results are conducted to evaluate the effectiveness of the system in different vibration scenarios. The results demonstrate that the pendulum-spring damping system provides significant reduction in vibration transmission. The findings also highlight the role of the spring in furtherenhancingdampingefficiency. This system offers an innovative solution for applications requiring efficient vibration control, including in automotive, aerospace, and structural engineering.

Keywords: -Pendulum, Vibration Damper, Structural Stability.

1. INTRODUCTION

This research paper aims to investigate the performance of a vibration damping system that incorporates a pendulum and mass. Through theoretical analysis and numerical simulations, the paper explores the system's ability to absorb and dissipatevibrationalenergyefficiently.Thestudyalso xamines key factors, such as the length of the pendulum, the mass, and the damping coefficient,
in determining the system's effectiveness in The SPPTMD leverages internal resonance and controlledcollisionstodissipateenergy,effectively reducing seismic responses in high-rise structures different vibration scenarios. [1]. The pendulum damper significantly reduces oscillations caused by wind loads. [2] Active control improves damping efficiency, minimizing bridge displacement during earthquakes. [3]. Composite materials improve durability and energy dissipation capabilities [4]. pendulum spring system offers superior vibration damping compared to traditional vertically installed springs.[5]. Optimized designs improve damping efficiency, making buildings more resistant to external forces[6]. Hybrid systems provide enhanced vibration reduction compared to traditional damping methods[7]. Active control improves damping efficiency, minimizing bridge displacement during earthquakes.[8]. Research contribute to the development of more efficient passive vibration damping solutions, with potentiala pplicationsindiverseengineeringfields. The use of a pendulum and mass-based damping system offerssever al advantage so verconv entional damping solutions. It allows for simple, low-cost construction while being adaptable to different vibration frequencies and amplitudes. Additionally, this system can be designed with minimal space requirements, making it suitable for various engineering applications, including vibration isolation in machinery, reduction of structural resonances in buildings and bridges, and noise control in automotive systems.

2.1 Needo fan attachment

Reason for Selection of Vibration Damping System Using Pendulum and Spring:
Solutions: The pendulum and spring-based vibration damping system offers an efficient method to absorb and dissipate vibrational energy. The pendulum swings in response to brations, while the spring provides additional resistance to motion, resulting in a significant reduction in oscillation amplitudes. The pendulum's length and the spring constant can be adjusted to tune the system to the specific vibration frequencies of the structure or machinery being damped. This customizability allows the system to target resonant frequencies effectively, providing maximum damping at the critical frequencies where vibrations are most problematic

2.2 Problem tatement

- Despite advancements in vibration control technologies,excessivevibrationscontinueto pose challenges in various engineering fields, includingmachinery,automotivesystems,and structural components.
- Traditional damping systems often lack efficiencyinaddressingvibrationsatspecific frequenciesorvaryingamplitudes,leadingto issues like material fatigue, reduced system performance, and noise.
- There is a need for more adaptable, cost- effective, and reliable vibration damping solutions that can provide consistent performanceacrossarangeofconditions.
- This project proposes a vibration damping system using a combination of pendulum and spring mechanisms, designed to absorb and dissipatevibrationalenergyeffectively,offeringa simple, efficient, and low-cost solution for vibration control in mechanical and structural applications.

2. OBJECTIVES

- DesignaVibrationDampingSystem:Developa vibration damping system that combines the characteristics of a pendulum and a spring for effective vibration reduction
- Energy Absorption and Vibration Mitigation: Focus on optimizing the system to absorb and mitigate vibrations across various frequencies, improving mechanical system stability.
- StudyDynamicBehavior**:**Analyzethedynamic response of the pendulum-spring system, including resonance, damping coefficient, and external force effects.
- Mathematical Modeling and Simulation: Use mathematical modeling and simulations to predictandoptimizethesystem'sperformance.

3. METHODOLOGY

The vibration damping model was constructed using metal plates, a pendulum, a spring, and a wooden box. First, the metal plates were cut and shaped to form a rectangular frame, which was then firmly secured to the wooden base usingboltsandscrewstoensurestability.After assembling the frame, the spring system was installed in an X-configuration within the structure to enhance damping efficiency. The springs were carefully tensioned to effectively absorb vibrations. Next, the pendulum was attached to the top of the frame using a strong thread, ensuring that the suspended mass was adequate for oscillation control. A wooden plank was fixed horizontally within the frame toprovideadditionalsupportforthestructure. The suspension point of the pendulum was secured tightly to prevent unwanted movement. Once all components wereinplace, the final assembly was checked for stability

3.1 ACTUALMODEL: -

3.2 COMPONENTSUSEDINMODE

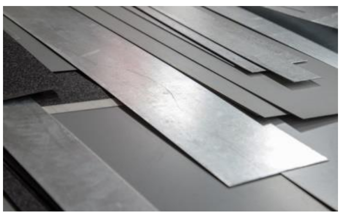


Fig.1:MetalSheet

Fig.2 :Base/Woodenblock

Fig.3:Pendulum

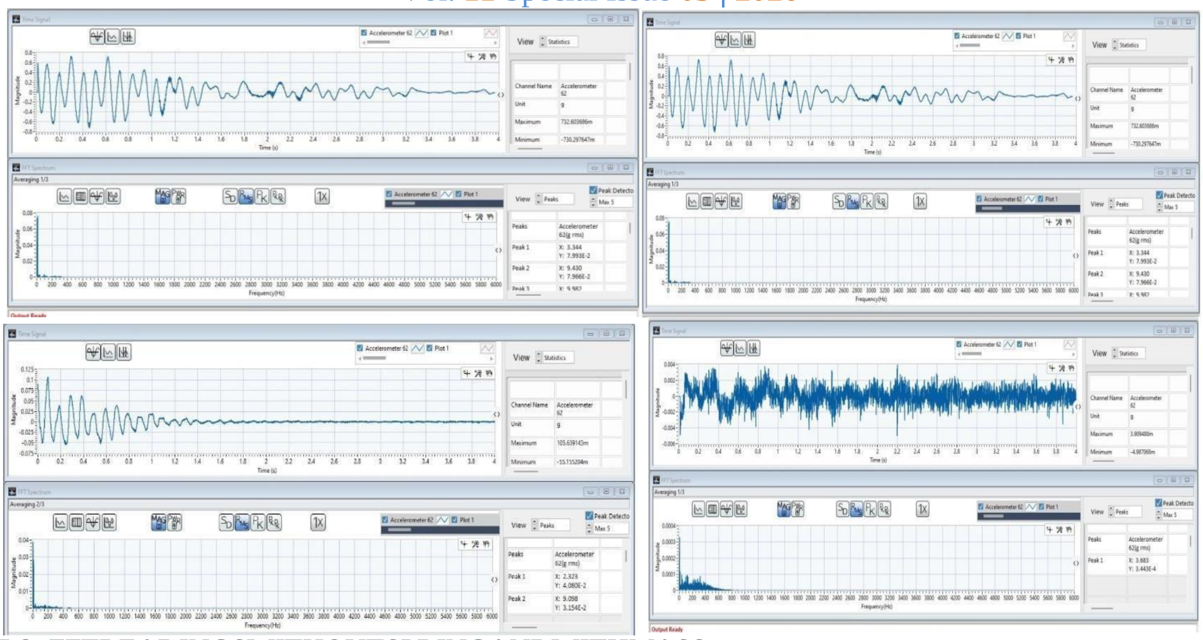
Fig.4:Spring

4. PROCEDURE

Step1:Spring+PendulumSystem
3.2.1 Thetestmassisconnectedtoboththespringand pendulum simultaneously.
3.2.2 Thesystemisgivenaninitialdisplacementand released.
3.2.3 TheFFTanalyzerrecordsthevibrationresponse,and the damping behavior is observed.
Step2:OnlyPendulumSystem
3.2.4 Thespringisremoved,andthetestmassisattached only to the pendulum.
3.2.5 Thesystemisdisplacedandallowedtooscillate freely.
3.2.6 TheFFTmeasurementistakentoanalyzethe damping effects of the pendulum alone.
Step3:OnlySpringSystem
3.2.7 Thependulumisremoved,andthetestmassis suspended only by the spring.
3.2.8 Thesystemisdisplacedandreleasedtooscillate.
3.2.9 The FFT analyzer records the frequency response, evaluatingthedampingcharacteristicsofthespring alone.
Step4:FreeBody(NoDampingSystem)
3.2.10 The test mass is placed without any damping components(neitherthespringnorthependulum).
3.2.11 Thesystemisexcitedtooscillatefreely.
3.2.12 The FFT measurement is taken to observe the undampedvibrationbehaviorandcompareitwiththe previous cases.

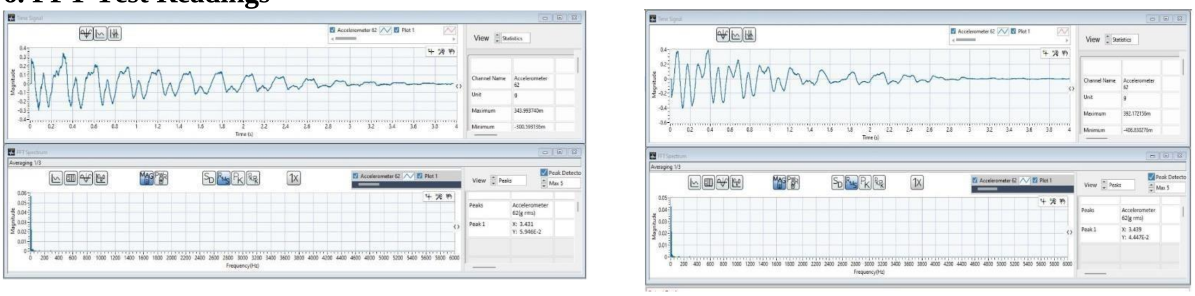
5. FFT TEST ANALYSIS READINGS: -

5.1 Fft readings with spring and with mass: -

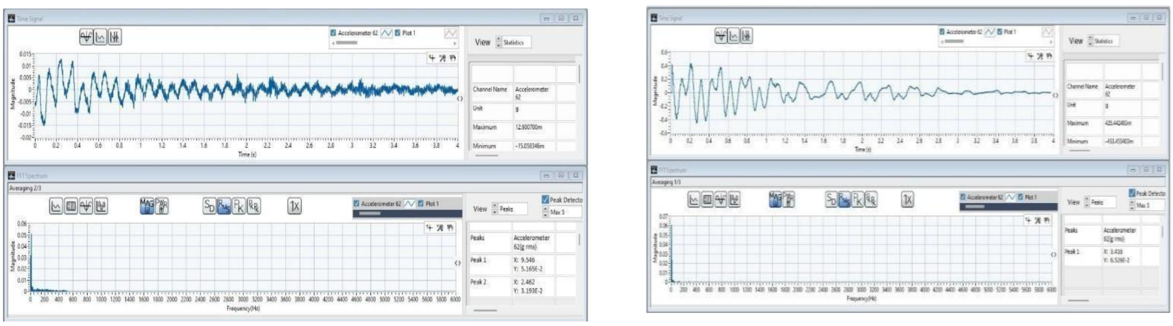


5.2 FFTREADINGSWITHOUTSPRINGANDWITHMASS
5.3FFTREADINGSWITHSPRINGANDWITHOUT MASS

6. FFT Test Readings



1.1. FFTREADINGSWITHSPRINGANDWITHMASS



6.2FFTREADINGSWITHOUTSPRINGANDWITH

Sr. No	Length (Cm)	Timetostop(Sec.)	Frequency (Hz)	Average
1	18	31	2.8	4.8
2	18	30	2.8	
3	18	30.9	2.8	

6.3FFTREADINGSWITHSPRINGANDWITHOUTMASS

Sr. No	Length (Cm)	Timetostop(Sec.)	Frequency (Hz)	Average

1	**0**	**17.80**	**3.4**	**3.4**
2	**0**	**17**	**3.4**	
3	**0**	**12**	**3.4**	

6.4FFTREADINGSWITHOUTSPRINGANDWITHOUTMASS

Sr. No	Length (Cm)	Timetostop (Sec.)	Frequency (Hz)	Average
1	**0**	**38.48**	**2.5**	**2.4**
2	**0**	**25.17**	**2.3**	
3	**0**	**32.53**	**2.4**	

7. CONCLUSION: -

The spring-pendulum system effectively demonstrateditsabilitytoreducevibrationsinthe setup. The interaction between the pendulum's inertia and the restoring force from the spring resulted in a noticeable damping effect on oscillations. By tuning the parameters such as the spring stiffness, pendulum mass, and damping coefficient, the system was able to absorb and dissipate energy from the vibration

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