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Design Methodology For Particle Damping

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ABSTRACT

Focused research in the area of Multi-Particle Impact Damping (MPID) has resulted in new methods of characterization and prediction. An analytical method has been developed, based on the particle dynamics method, that uses characterized particle damping data to predict damping in structural systems. A methodology to design particle damping for dynamic structures will be discussed. The complete design methodology has been validated in "proof-of-methodology" testing on a structural component in the laboratory. We focus our attention on the particle damping effect of the cantilever beam under the forced vibration, which has potential application to variety of systems. Multi physics live link for FEM is conducted using this developed model creatively. The dynamic response of the structure with the particle damper can be predicted in a finite element model of a structure. Meanwhile, the influence of the position, packing ratio of the damper on damping effect of particle damping are studied. Tungsten carbide particles are embedded in the enclosure attached to the beam. Although it is nonlinear, a strong rate of energy dissipation is achieved within a broadband frequency range. The results show that the particle damping effect is heavily dependent on the vibration amplitude of the structure and packing ratio. Composite materials like Reinforced fibre polymer, epoxy resin, fibre glass, glass reinforced epoxy etc will be used.

Keywords— **Beam Type, Cavity, Composite materials, Frequency, Mass Ratio, Packing Ratio, Particles Mass.**

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I. INTRODUCTION

Particle damping is a derivative of impact damping where multiple auxiliary masses of small size are placed in a cavity attached to the vibrating structure. Particle damping can perform at elevated temperatures where most other forms of passive damping cannot. Studies conducted over recent years have demonstrated the effectiveness and potential application of particle dampers, and have shown that particle dampers are highly nonlinear dampers whose energy dissipation, or damping, is derived from a combination of loss mechanisms. The relative effectiveness of these mechanisms changes based on various system parameters. A simulation technique has been developed which captures the complex interactions of the loss mechanisms in a particle damper. An outline of the particle damper design methodology is presented. In recent years, particle damping techniques have been further investigated but many factors still need to be considered while applying the particles for obtaining significant damping, such as particle size, packing ratio, hole size, position, and so on. Based on extensive experiments on three structural objects – beam, bond arm and bond head stand, the objective of this paper is to provide design guidelines for utilizing particle damping and facilitate the application of particle damping for effective vibration suppression. Particle damping is a type of impact damping where multiple particles are placed inside the cavity of vibrating structures. Studies conducted recently have shown the effectiveness and potential application of particle dampers. Particle damping is used to increase structural damping by filling particles in an enclosure attached to the vibrating structure. [5]

II. METHODOLOGY

- Determine characteristics of the undamped system.
- Determine appropriateness of particle dampers.
- Select preliminary particle damper configuration.
- Determine characteristics of the undamped system with adjusted mass.
- Evaluate damper effectiveness using the particle damper simulation technique.
- FFT analyser is used to determine the frequency.
- Accelerometer is used to determine the vibrations.
- CAD model is used for software analysis or with the use of ANSYS.
- Spring stiffness equation, $k = mWn^2$

III. FREQUENCY & PACKING RATIO

The packing ratio of particles is one of the key factors that affect the effectiveness of vibration suppression using particle damping technique. Beam experiments under various conditions are performed. The packing ratio is defined as the ratio of the amount of granules filled in a hole to the total amount a hole can be filled. Under one specific packing ratio, particles with four ranges of diameters, 0.3 ～ 0.5 mm, 0.5 ～0.71 mm, 0.71 ～1.0 mm and 1.0 ～1.4 mm, are used. The relationship between the frequency and packing ratio can then be plotted in Fig. 1, where the fitting curve with a polynomial function is also shown. With those results shown in Fig. 1 the packing ratio of particles can be initially decided according to the main frequency of a structure. This may not be the best packing ratio for the highest damping, but it would be a better one as the rule of thumb. Based on that, it can be found out that vibration suppression of the structure with lower packing ratio is effective at low frequency range as compared to higher frequencies. **[2]**

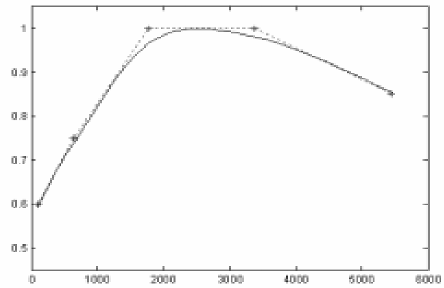

FIG. 1 Frequency vs Packing ratio

A. PARTICLE CHARACTERISTICS

TABLE NO.1 Particles & Respective sizes

SR NO.	PARTICLE WITH THEIR SIZES	DENSITY (g/cm^3)
1	Copper - 4.75mm	8.96
2	Copper - 2.36mm	8.96
3	Lead - 3.2mm	11.34
4	Lead - 4.75mm	11.34

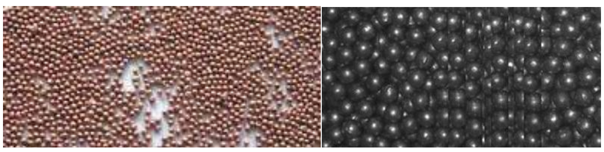

FIG. 2 Particle samples of different sizes

B. DAMPER DESIGN GUIDELINES

Due to the complex interactions of the loss mechanisms in a particle damper and the large number of parameters affecting the damper performance, it is extremely difficult to explicitly define a particle damper configuration for a particular application. However, based on the damper behaviour observed in experimental testing and analytical simulations, design guidelines have been established. Brief details on the experimental and analytical studies performed are given in the following paragraphs, and are followed by a list of key design guidelines. Experimental studies have been performed using a simple cantilever beam. The majority of these studies use impact-induced free ringdown testing, with some sine-dwell type measurements also taken. A removable capsule is attached near the free end of the beam such that the particle and/or cavity configuration can be changed relatively easily. The basic test setup is shown in Figure 3. Experimental displacement or acceleration data is recorded over the ring down time.

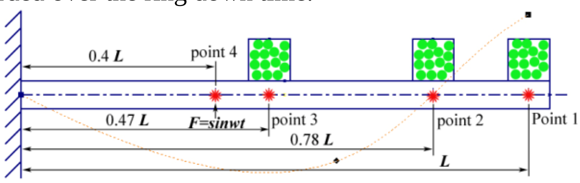

FIG.3. Emplacements of the particle damper on the beam

C. KEY DESIGN GUIDELINES

i. Total particle mass appears to have a fairly significant effect on damping for both single particle and multiple particle dampers. Increasing the mass tends to increase damping.

ii. Conversely, decreasing the mass tends to reduce damping. As might be expected, changes in the total particle mass can lead to a fairly significant shift in the frequency of peak response.

iii. Increases in the coefficient of friction or visco elasticity of the particles tend to increase the damping for single particle dampers. For multiple particle dampers, very little effect, or perhaps even a slight adverse effect, on the damping is observed.

iv. For single particle dampers, orienting the dampers such that gravity is in the direction of the vibratory motion tends to reduce the damping. The orientation of gravity appears to have much less effect on dampers with multiple particles.

v. Both single and multiple particle dampers appear to exhibit maximum damping at an optimum excitation level. Lesser damping is observed at excitations above and below this specific level.

vi. This relationship is closely linked to the interior dimensions of the cavity, particularly the length of the cavity in the direction of the vibratory motion.

vii. Single particle dampers appear to be more sensitive to changes in the various particle damper parameters. This result illustrates a potential advantage of multiple particle dampers in that precise tuning of the damper parameters may be less critical.

viii. At times, both the single and multiple particle dampers may cause random, somewhat chaotic behaviour of the damped system (e.g. the system may exhibit several local response peaks instead of a single resonant peak). This behaviour occurs more commonly in systems where the particle damper is contributing significant damping and may result due to slight mistuning of the damper parameters.

D. SCOPE OF RESEARCH

i. Determine the characteristics of undamped and damped system by considering various types of beams.

ii. Determine the characteristics of undamped and damped system by considering various types of cavities.

iii. Determine the characteristics of undamped and damped system by considering different particle size.

iv. Determine the characteristics of undamped and damped systems by considering different mass ratios.

v. Determine the characteristics of undamped and damped system by considering different packing ratios.

IV. CONCLUSION

It reviews vibration reduction with the use of different types of particles. Composite materials like reinforced polymer, glass fibre and glass reinforced epoxy are used. Frequency calculated with the help of FFT.

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