High Damping Characteristics of an Elastomer Particle Damper

Marcelo Bustamante, Samir N. Y. Gerges and Erasmo F. Vergara

Federal University of Santa Catarina, Department of Mechanical Engineering, Laboratory of Vibration and Acoustics, Campus Universitario, P.B. 476, Trindade, Florianopolis, SC, CEP 88040-900, Brazil

Jorge P. Arenas

Institute of Acoustics, University Austral of Chile, PO Box 567, Valdivia, Chile

(Received 16 September 2014; accepted 14 December 2015)

Research testing has led to the development of an Elastomer Particle Damper (EPD), which can add considerable damping to a structure by directing the vibration to a set of interacting elastomer particles through a rigid connection. This vibration treatment presents highly nonlinear behavior that is strongly dependent on both the vibration amplitude and frequency. Curves of damping loss factor (DLF) of an EPD system with vertical motion as a function of frequency and acceleration are reported herein. The results show that the elastomer particle damper has two distinct damping regions. The first region is related to the fluidization state of the particles, as described in the literature, obtained when the damper is subjected to vertical acceleration close to 1 g and frequencies below 50 Hz. The second region presents high values of DLF to acceleration values lower than 1 g, and the frequency range is dependent upon the stiffness of the particles. A high degree of effectiveness is achieved when the working frequency of the elastomer particle dampers is tuned to a natural frequency of a plate and when they are strategically located at points having large displacement. The performance of EPDs was compared with that of a commercial constrained layer damping installed in an aircraft floor panel. The EPDs achieved an acceleration level attenuation in the aircraft floor panel similar to that of the commercial constrained layer damping system.

1. INTRODUCTION

Traditional damping treatments use viscoelastic materials to convert strain energy into heat energy through the relative internal motion between molecules. Energy dissipation can be provided to a vibrating structure by a constrained damping layer in which a viscoelastic material is sandwiched between the structure to be damped and a stiff metal layer. Then, bending of the composite produces shear and the mechanical energy is dissipated in the middle layer as heat. These materials have been used quite successfully to address problems of noise and vibration control.[1] However, the temperature sensitivity in polymer-damping processes is a major disadvantage.[2] Another drawback is that the damper properties are strongly dependent on frequency and strain.

As an alternative, the use of particle dampers (PDs) can be an interesting solution. PDs are stiff enclosures containing a large number of either elastic or viscoelastic particles (e.g. sand, ball bearings, and elastomer balls) as shown in Fig. 1. Damping performance of PDs is usually not strongly temperature dependent and thus they can be used in harsh environments. Several studies have been carried out on PDs, mainly with metal spheres, providing modeling and experimental results.[3–7] However, in this study, elastomer particles were used because the interaction between them is quieter, which is an important aspect in noise and vibration control.

PDs can be added to a structure in two ways: 1) by attaching an enclosure to an exterior surface or 2) by partially filling manufactured or pre-existing voids inside the structure with particles.

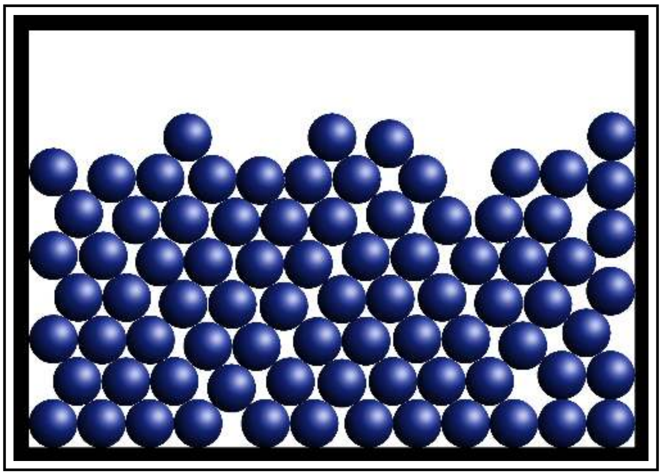

Figure 1. Schematic diagram of a particle damper.

The operating principle of PDs is based on energy dissipation through multiple inelastic collisions, interparticle friction, and friction between the particles and the walls of the container. The resulting system is highly nonlinear. Its damping capacity is greatly dependent on the level of acceleration which the container undergoes. There are a significant number of parameters affecting the damper performance. These include particle size, shape, number and density, the size and shape of the enclosure, and the properties that affect the particle-particle and particle-enclosure interactions, such as the coefficients of friction and restitution.[3]