Experimental and numerical investigations on parameters influencing energy dissipation in particle dampers

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ABSTRACT

Lightweight designs are becoming increasingly important these days to reduce energy consumption and natural resources. However, a smaller weight typically causes a decrease in stiffness and non-negligible vibration amplitudes over a wide frequency range. One passive damping technique to reduce these vibrations is the use of particle dampers. Thereby containers attached to a vibrating structure or holes embedded in the vibrating structure are filled with granular material. Due to the structural vibrations, momentum is transferred to the granular material which interacts with each other. As a result, energy is dissipated by impacts and frictional phenomena between the particles.

Particle dampers show several advantages when compared to other existing passive damping techniques. They may be insensitive to temperature and environmental conditions, do not necessarily add significant mass and do not degrade in time. In literature it has been shown that they are at least as effective as other damping techniques, and the effectiveness is not restricted to a single frequency but exists over a broader frequency range [1].

The efficiency of particle dampers has been demonstrated experimentally in a few different engineering applications. However, so far the damper design has been based on very specific systems. This might be due to the fact, that the processes in the particle dampers are highly nonlinear and depend on a variety of different influence parameters.

In this presentation, experimental as well as numerical investigations on the energy dissipation of particle dampers alone are presented. Excluding the underlying vibrating structure, and concentrating on the particle damper enables to make general statements about the energy dissipation effects. Thus, the testbed consists only of the particle box with a free-free boundary condition and excited by an acceleration controlled shaker. A large frequency range and acceleration range can be used. The corresponding numerical model is described by the Discrete Element Method [2] using continuous contact models based on the contact law of Hertz and modifications to introduce energy dissipation by using a coefficient of restitution. An efficient contact search algorithm and time integration scheme is used.

A variety of influence parameters are analyzed in simulation and experiments. These are amongst others the excitation frequency and acceleration, the filling ratio of the particle box, the particle material, and particle size. The experimental results are compared with the simulation results showing good agreement. Moreover, the influence of the coefficient of restitution and the coefficient of friction on the simulation results is investigated. A high dependency of the energy dissipation on the excitation frequency and acceleration is observed. For the parameters filling ratio and material pairing different choices perform better or worse for different excitations and no general statements are possible. However, the numerical model can be used to find an optimal parameter set to maximize energy dissipation.

REFERENCES

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