ABSTRACT

Duncan, Matthew R., M.S.M.E., Purdue University, December, 2004. An Investigation into the Damping Performance of Single and Multiple Particle Impact Dampers: Major Professors: Dr. Carl Wassgren and Dr. Charles Krousgrill, School of Mechanical Engineering.

Impact dampers are simple devices that can be used on a wide range of structures, yet their analysis and optimization tends to be difficult due to the large number of parameters affecting their performance. Numerous experiments and analytical models have been developed to study the performance of the impact damper, but conflicting results, limited parametric studies, and specialized tests have made thorough understanding and design guidelines elusive.

This thesis presents results from computer simulations used to investigate the damping performance of single and multiple particle impact dampers over a wide range of excitation frequencies and amplitudes, particle-to-structure mass ratios, lid clearance ratios, viscous structural damping ratios, and coefficients of restitution. Measurements of the damping performance, particle flight times, and structure contact times are presented. Performance at both the structure's undamped natural frequency and off-resonant conditions are studied in depth.

For the single particle impact damper, the particle trajectories are studied and two symmetric impact per cycle motion is determined to be the most effective. Maximum damping at a fixed oscillation frequency occurs at an optimal lid height that increases with increasing mass ratio, increasing viscous structural damping ratio, but decreases with coefficient of restitution. The corresponding maximum degree of damping increases with increasing mass ratio and coefficient of restitution, but decreases with increasing viscous

structural damping ratio. Field plots of the damping ratio are also presented as functions of oscillation amplitude and frequency to demonstrate the damper performance over a range of design parameters and operating conditions.

Multiple particle simulations show that their performance is very similar to single particle impact dampers for the same dimensionless parameters. Larger coefficients of restitution increase maximum damping and the differences between the multiple and single particle case for the same dimensionless parameters. Small changes in the dimensionless frequency or amplitude can cause the particles to transition from two symmetric impact per cycle motion to asymmetric motion, resulting in large transitions in the damping ratio.