Vibration Damping Characteristics of Non-blocking Particle Damping in Conical Cavities (Postprint)

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Abstract

The cavity geometry of non-obstructive particle dampers (NOPD) significantly modifies the pressure distribution characteristics between particle layers, thereby influencing their vibration suppression performance. The dynamic characteristics of conical-cavity NOPD were analyzed using the discrete element method (DEM). First, a DEM-based numerical model for NOPD was constructed and experimentally tested, with model reliability validated against experimental results. The influence mechanism of structural parameters of conical-cavity NOPD—including particle filling ratio, volume ratio parameter (ratio of single particle volume to cavity volume), and wall inclination angle—on its vibration damping performance was discussed in detail. The analysis results demonstrate that conical-cavity NOPD exhibits optimal damping effect at a filling ratio of 0.6, and this optimal value is independent of wall inclination angle. Comparative analysis further reveals that at filling ratios below 0.6, conical-cavity NOPD enhances energy dissipation through inter-particle collisions, thereby demonstrating superior vibration damping performance compared to cylindrical-cavity NOPD; however, when the filling ratio exceeds 0.6, the conical structure restricts particle motion, leading to performance degradation. Parameter optimization calculations indicate that the optimal wall inclination angle range is 45°–55°, while the optimal volume ratio parameter is determined to be 0.00032.

Full Text

Preamble

The mathematical framework is defined through a comprehensive series of equations establishing the relationships between core variables. The notation system employs symbols—including FaW, SI, PO, NN, K, O, and W2V—to represent fundamental components of the model architecture. These equations collectively establish foundational relationships between model parameters, activation functions, and optimization objectives that are systematically referenced throughout the subsequent analysis.

Note: Figure translations are in progress. See original paper for figures.