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Optimal design of tuned particle damper for vibration control of railway systems

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ABSTRACT

A novel rail damper, incorporating particle damping technology, was introduced to reduce train-induced vibrations. To investigate the dynamic interactions between the rail and the tuned particle damper (TPD) system, a mathematical model was established. This model explored how various factors, such as equivalent damping, the proportion of moving particles, and the TPD to rail system frequency ratio, affect the system's performance to control rail vibrations.

Validation of the model was performed using impact hammer tests that explored different particle materials, sizes, and fill ratios. The simulation's frequency response functions and acceleration time histories showed a high degree of correlation with the experimental data. Furthermore, the TPD system's optimal parameters were determined by minimizing the mean-square modal displacement response ratio for the rail structure, comparing scenarios with and without the TPD under external excitations. It is noted that the application of the proposed TPD yielded a significant dampening of vibration responses across a broad frequency spectrum. Finally, to assess the TPD system's effectiveness in vibration control, numerical simulations were conducted on an extended rail structure subjected to train-induced vibrations.

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