Multimodal Vibration Control against Flexural Vibrations of Railway Vehicle Carbodies Using Active Mass Dampers

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1. Introduction

Improvements in passenger ride comfort can be achieved in many new designs of railway vehicles by reducing the vertical flexural vibrations of passenger carbodies. In particular, multiple flexural vibration modes that occur around 10 Hz are important. This frequency is in the range where the passengers are sensitive to vertical accelerations and affect the riding comfort greatly. Accordingly, a method for controlling those vibrations simultaneously is required. To meet this requirement, we proposed a multimodal vibration control method using Active Mass Dampers (hereinafter called "AMDs") and developed a compact AMD dedicated for that purpose.

2. Compact Active Mass Damper (AMD)

We newly developed a compact AMD consisting of a moving mass supported by an air spring and a linear actuator using permanent magnets as shown in Figure 1. This device reduces vibrations by providing an object for vibration control with inertial reaction generated when the upper moving mass is moved by the actuator. The gross mass per device is 70 kg, and the dimensions measure 390 mm long, 300 mm wide and 226 mm high. For this research, two devices were used to provide multimodal vibration control.

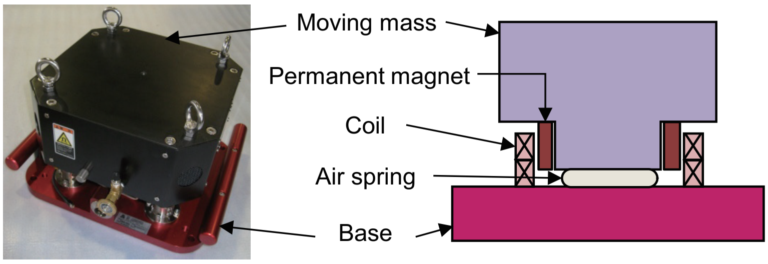

Fig. 1 The developed compact AMD

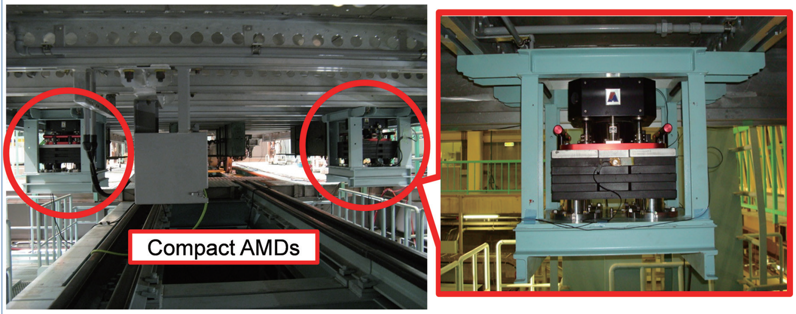

Fig. 2 Compact AMDs fitted to the underfloor of the vehicle

3. Validation of vibration control effect

In order to validate the effect of multimodal vibration control using AMD technology, we performed an excitation test. We installed two compact AMDs under the floor of the central area of a Shinkansen-type test vehicle as shown in Figure 2 and simulated the real running state (at a running velocity equivalent to 240 km per hour) in the rolling stock testing plant at the RTRI. The acceleration PSD (power spectrum density) on the floor which is the closest to the central window of the carbody is shown in Figure 3. The PSD shows large peaks corresponding to two flexural vibration modes at 9 and 11 Hz when there is no vibration control. Note that those peaks are drastically reduced when the AMD control is provided. Thus, we were able to verify from the above result that the newly developed compact AMDs are equipped with the characteristics necessary to achieve multimodal vibration control for railway vehicles. Although this article describes the excitation test results at RTRI's rolling stock testing plant, we also performed running tests on commercial lines for Shinkansen trains and conventional-line limited express trains. As a result, we have confirmed that the multimodal vibration control using compact AMDs is also effective in the real running state.

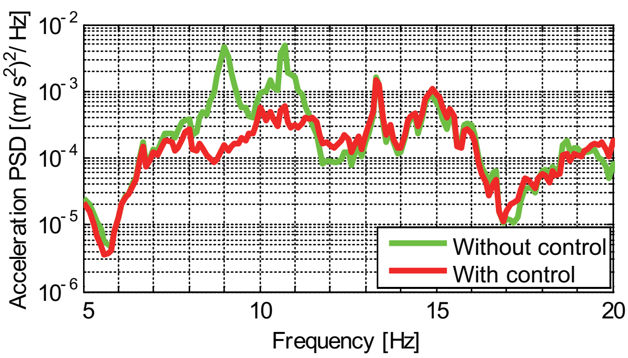

Fig. 3 Acceleration PSD measured under the central window
(Simulated running excitation corresponding to 240 km/h)