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Multi-Mode Vibration Suppression of High-Temperature Superconducting Maglev System Via Negative Resistance Electromagnetic Shunt Damper

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The high-temperature superconducting (HTS) maglev system has tremendous possibilities for future high-speed transportation owing to its salient superiorities of self-stable. However, previous study had indicated that the relatively low damping of HTS maglev system may cause the undesired large-amplitude nonlinear vibration in system. To solve that, electromagnetic shunt damper (EMSD), which usually consists of electromagnets, permanent magnets and shunt impedance connected to the terminals of the coils, was introduced for damping improvement in HTS maglev system and had shown its effectiveness in vibration suppression. But EMSD has its limits, it only works most effectively in a narrow bandwidth near the natural frequency in a single mode due to the fixed and unchanged parameter value of shunted branch. Hence, a new negative resistance electromagnetic shunt damper (NR-EMSD) is employed to improve the vibration suppression performance of HTS maglev system. The negative resistance offsets the inherent resistance of the electromagnet coils and as a result the induced current of the circuit would increase, which will significantly enhance the performance of vibration suppression. And the change of resistance of closed circuit makes it feasible to suppress the multi-mode vibration. In this paper, mathematical model of NR-EMSD and governing equation of the HTS maglev system are established. The stability analysis is investigated to determine the design rules of negative resistance. And experiments are carried out using EMSD method and NR-EMSD method respectively for contrast. The results shows that the NR-EMSD can not only increase the damping of the system notably, but also has a better performance than passive EMSD. And multi-mode vibration suppression could be achieved simultaneously. This work may provide references for further practical application in HTS maglev system.

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