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Dissertation Abstract

Report no.	(Course-based) No. 1103	Name	Asief Javed
Dissertation title	Vibration reduction by varying stiffness control in passive magnetic suspension mechanism (パッシブ磁気浮上機構における可変剛性制御を利用した制振)		

Abstract

This study investigates the lateral vibration reduction by applying stiffness control in a vertically active magnetic suspension system operating in differential driving mode.

In a vertically active magnetic suspension system, the normal direction is unstable, as a result, it is necessary to control for stable suspension. On the other hand, edge effect provides some stability in lateral directions. However, due to less damping, vibration can easily induce in these directions. The floator needs long time to return to its equilibrium position as a result of small disturbance. The strategy of stiffness control is applied to such system to attenuate the lateral vibrations.

Firstly, the variable stiffness control is applied to a single-degree-of-freedom magnetic suspension system. The floator is suspended with the help of leaf spring which restricts the movement of the floator to one lateral direction. An impulse disturbance is applied to the floator by a voice coil motor. The results show suppression of vibration in lateral direction. The effect of noise on the control strategy is investigated by adding band limited white noise in the displacement signal of the floator. The modified control works better under noisy condition, as the control current in modified control depends on the amplitude of the product of displacement and velocity. Moreover, the discussion of the switching stiffness control and modified stiffness control while misalignment exists between the floator and the electromagnets is included in this study.

Secondly, a device is developed to study the varying stiffness control strategy on a three translational motions magnetic suspension system. In the three-degree-of-freedom system, two electromagnets are arranged in normal direction driving in differential mode. These two electromagnets are used to actively suspend the floator (ferromagnetic ball) as well as to reduce vibration in lateral directions. An optical sensor is developed to measure the displacement of the ball in three translational directions. A voice coil motor with internal bearing is built to disturb the suspended ball in lateral direction. The switching stiffness control and the modified stiffness control are applied to reduce lateral vibrations. Proportional-integral-derivative (PID) control is applied in normal direction to achieve suspension of the ball. The lateral vibration is attenuated by both of the control strategies. Increasing values in steepness parameter in modified control can reduce the settling time for same control current. The control strategy to reduce lateral vibration as mentioned is simple compared to others such as PID control, robust control. The current-force coefficients of the electromagnets play an important role as incorrect value of that induces vibration in normal direction while applying varying stiffness control, and lateral vibration cannot be reduced.