Title:

Instability Induced by Iron Losses in Rotor-Active Magnetic Bearing System

Authors:

Naohiko Takahashi
Hitachi Industries Co., Ltd.
603 Kandatsu-machi, Tsuchiura-shi, Ibaraki, Japan, 300-0013
Tel. 81-298-32-8026
Fax 81-298-31-6533
Email: naohiko_takahashi@pis.hitachi.co.jp

Minoru HIROSHIMA
Hitachi Industries Co., Ltd.
603 Kandatsu-machi, Tsuchiura-shi, Ibaraki, Japan, 300-0013
Tel. 81-298-32-5942
Fax 81-298-32-8022
Email: minoru_hiroshima@pis.hitachi.co.jp

Haruo MIURA
Hitachi Industries Co., Ltd.
603 Kandatsu-machi, Tsuchiura-shi, Ibaraki, Japan, 300-0013
Tel. 81-298-31-6692
Fax 81-298-31-6533
Email: haruo_miura@pis.hitachi.co.jp

Yasuo FUKUSHIMA
Hitachi Industries Co., Ltd.
603 Kandatsu-machi, Tsuchiura-shi, Ibaraki, Japan, 300-0013
Tel. 81-298-32-8026
Fax 81-298-31-6533
Email: yasuo_fukushima@pis.hitachi.co.jp

Key Words:

Unstable Vibration, Iron Loss, Unbalance Vibration Control, Thermal Bow, Active Magnetic Bearing

Abstract:

This paper presents an increasing rotor vibration equipped with active magnetic bearings (AMBs) and discusses the cause of the instability.

There are several papers that discuss unstable synchronous vibration caused by rubbing or thermal imbalance in the lubricant of bearings or liquid seals. Concerning AMBs, instability is sometimes caused by inadequate controller design, but it is not well known that the iron losses affect its control stability.

In rotational coordinate, the unbalance force is staying in a constant phase at fixed speed, so the magnetic force that compensates the unbalance force is also staying in a constant phase. This causes a steady distribution of iron losses on the rotor and makes a rotor bow by a thermal expansion. This thermal bow will increase unbalance vibration.

In this paper, the phenomenon of which the vibration vector is spiral along with time domain is presented. The interaction between unbalance control and a thermal bow through iron losses is focused, and the mechanism of the instability is revealed. In relation to this mechanism, differences of vector trajectory between two control laws (one is like spring, the other is like damper) are pointed out.

In order to verify the instability condition, a model including the thermal dynamics is proposed. Applying this model to a very simple example, the simplified criterion is presented for ease of understanding. How to avoid the thermal instability is discussed as the conclusion.