Design of hybrid thrust magnetic bearing for heavy rotating shaft considering self-weight compensation according to axial load.

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Motivation for research Magnetic bearings have been widely used in high-speed rotation system, machinery, aerospace, and high precision system because of the numerous advantages of non-contact rotating machines, such as a no wearing, low loss, long life span compared with conventional bearings, and absence of lubrication [1][2]. In the various types of magnetic bearings, thrust magnetic bearings with thrust collar are generally used for active position control of thrust direction, and the upper and lower air-gaps are designed in the same way. However, hybrid thrust magnetic bearing(HTMB) for heavy rotating shaft should be considered axial load at initial design stage since as the load increases, the force is generated asymmetrically. Therefore, the force acting on the upper part and the force acting on the lower part must necessarily be designed in different ways. In the case of a vertically driven shaft with a heavy impeller mounted vertically, because of the axial weight always acts as a load in the downward direction, the forces acting in the same air gap cannot be balanced, and the greater the weight of the shaft, the greater the imbalance of the axial force of the HTMB. Therefore, the position of the axial collar has to move further upwards or downwards in order to maintain the balance between the upper directional force and the lower directional force. The thrust collar must be located at position that the force of the upper and lower parts is in equilibrium for flexible control, but the closer the thrust collar is to the upper and lower core, the smaller the mechanical air-gap and the shaft may be damaged, or a lot of HTMB loss occurs since the current for HTMB control increase when the magnetic bearing force is imbalanced. Therefore, this paper deals with design of HTMB for heavy rotating shaft considering self-weight compensation according to axial load, and we believe that the proposed method is useful and effective in designing other models. **Design of thrust magnetic bearing considering self-weight compensation according to axial load** In this paper, the design and analysis of a HTMB for a 6kW 60,000-rpm-class spindle for micro-drilling machine are presented. This paper is divided into three main parts: the design of HTMB, the influence of self-weight that changes according to the axial load, and the redesign of HTMB considering self-weight compensation according to axial load. The first part focuses on the design of HTMB which use a finite element method (FEM), deals with a general design that does not consider self-weight according to axial load. The second part is based on the validation of the initial designs by experiments using a manufactured HTMB, and deals with the influence of self-weight that changes according to the axial load. Finally, redesign of HTMB for compensation self-weight with axial load, and validation of the results by the two-dimensional FEM, and then by experiments using a manufactured model. In a future study, a more specific comparison with an accurate design method in consideration of the self-weight with axial load, will be thoroughly investigated for its contribution to related researches and industrial applications.

[1] H. Eryong, and L. Kun, "A Novel Structure for Low-Loss Radial Hybrid Magnetic Bearing," *IEEE Trans. Magn*., vol. 47, no. 12, pp. 4725-4733, December, 2011. [2] K. Hijikat, S. Kobayashi, M. Takemoto, Y. Tanaka, A. Chiba, and T. Fukao, "Basic Characteristics of an active Thrust Magnetic Bearing with a Cylindrical Rotor Core," *IEEE Trans. Magn*., vol. 44, no. 11, pp. 4167-4170, November, 2008.

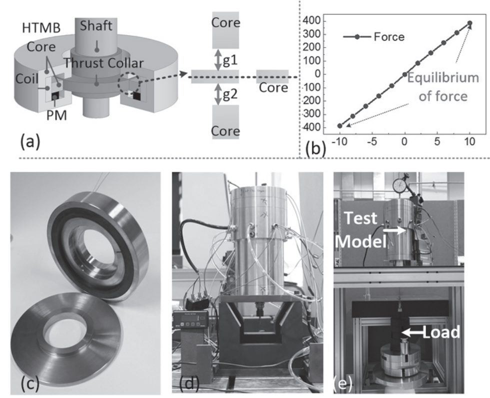

Figure 1. (a) the design concept of HTMB, (b) the magnetic force of initial design model, (c) the manufactured HTMB with the initial design method, (d), and (e) experiment set for confirming influence of self-weight with axial load.

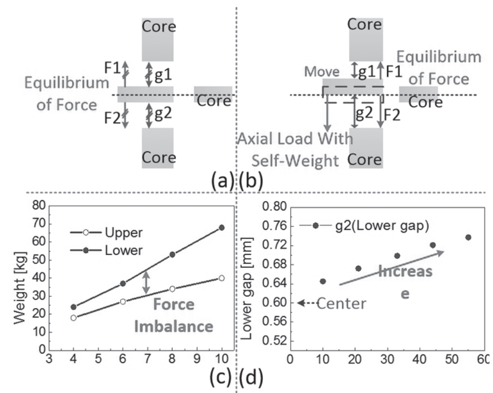

Figure 2. (a) the design concept of initial design model, (b) the redesign concept considering self-weight with axial load, (c) the experimental results of a model manufactured by the initial design method, and (d) the results of change in lower air-gap for balancing generated force according to self-weight with axial load.