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

Ji Hun Ahn[1,2], Jang Young Choi[1] , Cheol Han[1,2], Cheol Hoon Park[3] , Chang-woo Kim[2] , Tae-gwang Yoon[1]

1. R&D Department, MAGNETAR, Gajeongbukro-Ro, Yuseong-Gu, Daejeon, Korea
2. Department of Electrical Engineering, Chungnam National University, 220, Gung-dong, Yuseong-gu, Daejeon, Korea
3. Advanced Manufacturing Systems Research Division, Korea Institute of Machinery and Materials, Daejeon, Korea

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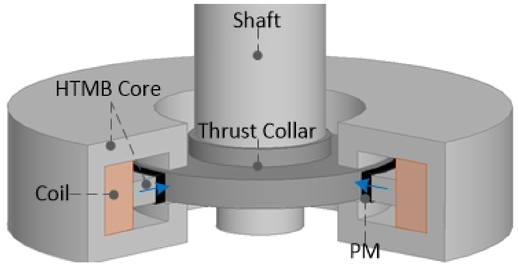
Background

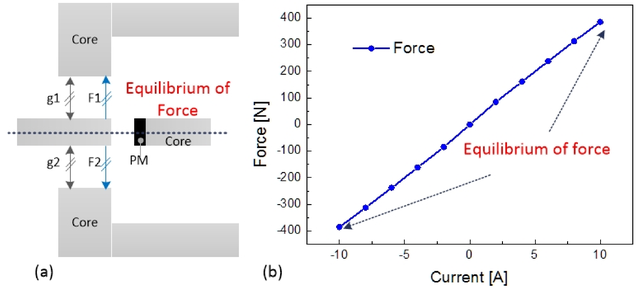
This paper deals with design of hybrid thrust magnetic bearing (HTMB) for heavy rotating shaft considering self-weight compensation according to axial load. In case of a vertically driven heavy shaft should be considered self-weight with axial load at initial design stage because of the axial weight always acts as a load in the downward direction. This paper deals with the problems of general magnetic bearings that do not consider axial loads and discusses the design of magnetic bearings considering axial loads, and it is validated by actual manufactured model.

Objectives

- ✓ 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 influence of self-weight that changes according to the axial load using a manufactured HTMB.
- ✓ 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.

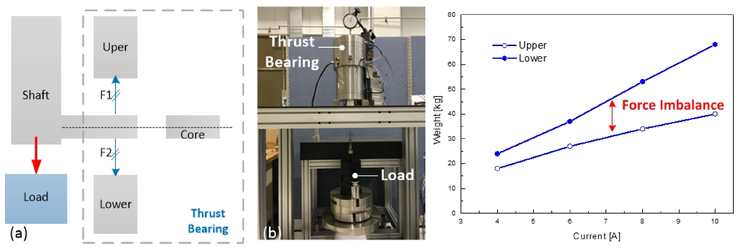


The design concept of general HTMB



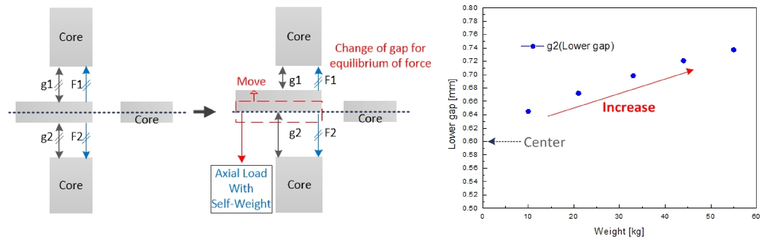
(a) 2-d conceptual illustration of general HTMB, (b) The results of axial force of general HTMB

- ✓ Radially magnetized ring magnet is installed with coil, and the flux path from the permanent magnet (PM) is symmetric with respect to the center line of the upper and lower sides of the pure iron core.
- ✓ The magnetic flux from the PM provides bias flux to the upper and lower gaps (g1 and g2) between the thrust collar and the pole face of the pure iron core.
- ✓ Thrust collar are used for active position control of thrust direction, and upper air-gap (g1) with lower air-gap (g2) are designed in the same way to generate the same magnetic force



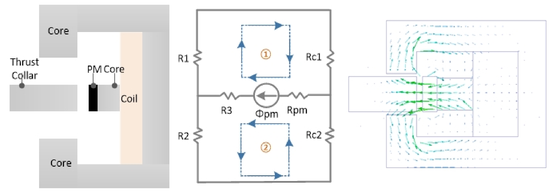
- ✓ The weight of the shaft always acts as the load in the downward direction.
- ✓ However, the vertically driven shaft with a heavy impeller mounted vertically, or heavy shaft, the forces acting in the same air gap cannot be balanced axial force because of the axial weight always acts as a load in the downward direction.
- ✓ Hence, the greater the weight of the shaft, the greater the imbalance of the axial force of the HTMB because the design considering the shaft load was not made at the initial design stage.

Influence of self-weight axial load

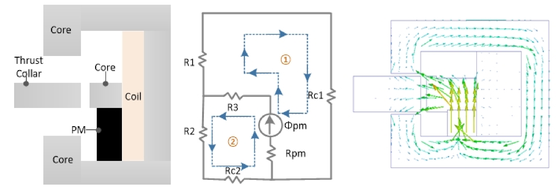


- ✓ The upper and lower air-gaps are designed in the same in order to dynamically control of thrust position generally, but when the axial load is large, in order to maintain the balance between the upper directional force and the lower directional force, the position of the axial collar has to move further upwards or downwards
- ✓ it can be confirmed that the position of the thrust collar to balance the force according to the shaft weight changes

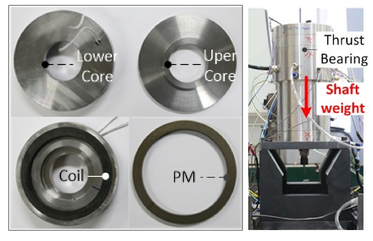
Results & Conclusion



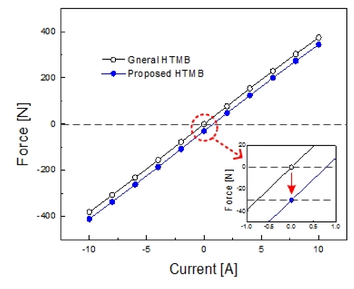
Concept with magnetic equivalent circuit and flux flow of general model

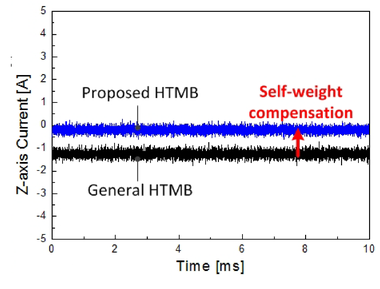


Concept with magnetic equivalent circuit and flux flow of proposed model



Manufactured proposed HTMB





- ✓ The same force is generated when a negative current and a positive current are input, but in order to compensate the shaft's weight, a force generated by the PMs should support the weight of the shaft when the input current is zero.
- ✓ the proposed HTMB which is designed considering self-weight compensation can confirm that the current for supporting the axial load is not applied. Therefore, it can be confirmed that the shaft is only supported by the force of the PM when the input current is zero.