Numerical Investigation of Dynamic Characteristics of a Downsized Aerostatic Circular Thrust Bearing with a Single Feed Hole

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Aerostatic bearings have been successfully applied to various precision machines because of their advantages, such as high accuracy of motion and low friction. Recently, the application of aerostatic bearings to very small devices has attracted considerable attention. In downsizing bearings, the velocity of air flow becomes very fast and easily exceeds supersonic velocity. Accordingly, it is expected that the inertia forces of air flow largely affect the bearing characteristics. In this study, we have performed analysis of an airflow in the bearing clearance of the downsized aerostatic circular thrust bearing with a single feed hole using CFD software.

Keywords: Aerostatic Bearings, Downsizing thrust bearing, Vibrating Surface, Static characteristic,

1. Introduction

Aerostatic bearings have been successfully applied to various precision machines because of their advantages, such as high accuracy of motion and low friction. Recently, the application of aerostatic bearings to very small devices has attracted considerable attention. In this paper, the static and dynamic characteristics of a small aerostatic circular thrust bearing with a single feed hole and 10 mm outer diameter were investigated numerically and experimentally. In the numerical calculations, the Navier–Stokes equations, the equation of continuity and the equation of energy were simultaneously solved using a commercial CFD software (ANSYS Fluent).

2. Methods

In this study, the commercial CFD software, ANSYS Fluent, was used to numerically obtain the gas flow that flows into the bearing clearance from the air supply hole and flows out from the outer circumference. Figure1 shows schematic views of the analysis models. In our previous study, Ishibashi et al. [1] performed analysis using the 2D model. However, large discrepancies between the numerical results and the experimental results in the dimensionless damping coefficient were confirmed. Therefore, in this study, although the analytic model is symmetric, the 3D model in consideration of the three-dimensional flow was used. To obtain dynamic characteristics of the bearing, a perturbation was applied to the moving part of the bearing. In this study, the perturbation was applied to the upper wall representing the thrust collar in a form of cyclic motion [1].

3. Results and discussions

Figure 2 shows comparisons between the numerical results and the experimental results. Figure 2 (a) shows the pressure distribution in the bearing clearance. The results obtained by CFD analysis are in good agreement with the experimental results. On the other hand, the Reynolds equation could not correctly predict the pressure drop region near the supply hole. As shown in Figs.2(b) to (d), for the static characteristics of the bearing, either the 2D model or the 3D model can be used to numerically predict the bearing characteristics. Regarding the dynamic characteristics, the experimental results and the numerical results are in good agreement for both the 2D model and the 3D model for the dynamic stiffness, but the 3D model has values closer to the experimental results for the damping coefficient. From the results above, it was clarified that although the bearing shape is axisymmetric, the three-dimensional flow has a great influence on the damping characteristics of the downsized aerostatic bearing treated in this study.

4. References

[1] Ishibashi K., Kondo A., Kawada S., Miyatake M., Yoshimoto S. and Stolarski T., Static and dynamic characteristics of a downsized aerostatic circular thrust bearing with a single feed hole. *Precision Eng.*,Vol.60,pp.448-457,2019

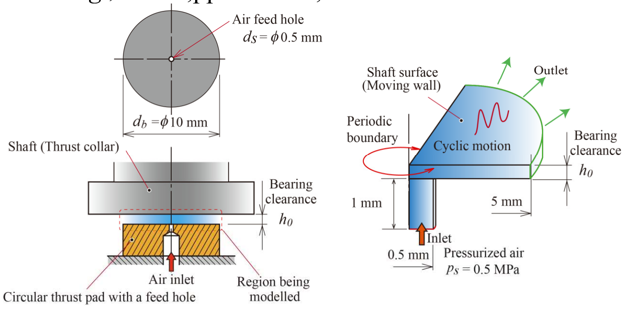

Figure 1: Schematic views of the aerostatic thrust bearing treated in this study.

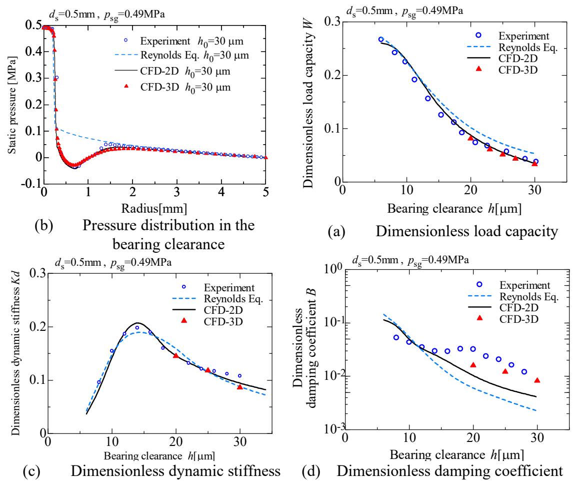

Figure2: Comparisons of analysis results and experimental results.