Optimum Design of Thrust Oil Bearing for Hard Disk Drive

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Abstract

This paper presents the application of optimization method developed by Hashimoto to design oil lubricated thrust bearing for 2.5 inch form factor hard disk drive (HDD). The designing involves optimization of groove geometry and dimensions. Calculation is carried out to maximize the dynamic stiffness of the thrust bearing spindle motor. Static and dynamic characteristics of the modeled thrust bearing are calculated using the divergence formulation method. Results show that by using the proposed optimization method, dynamic stiffnesses values can be well improved with the bearing geometries not being fixed to conventional grooves.

1. Introduction

HDD has been used as the main storage multimedia for electronics devices. Currently, HDD widely depends on oil lubricated fluid dynamic bearings (FDB). FDB is mainly supported by thrust and journal bearings. A schematic view of bearings in a 2.5 inch HDD is shown in Fig. 1.

FDB gives better performance characteristics compared to conventional ball bearings as it has high dynamic stiffness with additional of a much higher damping effects. These damping effect characteristics provide smaller non-repeatable run-out (NRRO). NRRO are the major contributor to the track misregistration in HDD read-write mechanism. Even though the repeatable run-out (RRO) of oil lubricated FDB is higher than the ball bearing spindle motor, the RRO can be corrected by a read-write servo. Therefore, to reduce NRRO and increase spindle performance is to improve the bearing performance.

Currently, groove geometries that are being widely used in HDD thrust bearings are mainly of a spiral or a herringbone grooved geometries. Some numerical analysis prediction of these grooves for HDD bearing performance have been conducted by several investigators[1-5]. There were also some attempts of improving the dynamic stiffness and damping of HDD spindle by introducing permanent magnetic thrust plates into the bearing spindle structure[6], or introducing magnetic fluid as lubricants[7]. However, there are very few attempt of finding an optimum design with a novel geometry to replace the conventional herringbone or spiral grooves for HDD. In the attempts of improving HDD performance, Hirayama et al.[8] proposed a non-uniform spiral groove for journal bearings to expand the critical bearing number for higher revolution speed of HDD spindle. The approach indicated that the novel non-uniform spiral grooves hydrodynamic bearing manage to increase the stability of rotation in high speeds.

This suggests that there is a probability of a furthermore improvement if the groove geometry is not being fixed to any conventional grooves, either spiral or herringbone grooves. Therefore, in this paper, by adapting the optimization method initiated by Hashimoto, a new optimum groove geometry and dimension to replace conventional grooves and increase the bearing performance of an oil lubricated 2.5 inch HDD had been calculated. The groove geometry and dimension of the thrust bearing for spindle motor is calculated using the hybrid method[9] with the improvement of dynamic stiffness *K*, being set as the objective function.

The optimization results showed that the dynamic stiffness of oil lubricated thrust bearing can be improved by introducing a new optimum geometry into the system. Vibration analyses were also presented to numerically verify the applicability of the improved bearings.

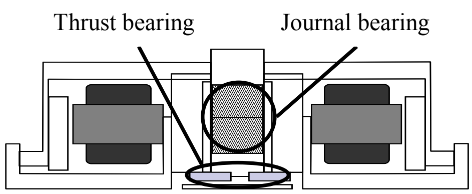

Fig. 1 Bearings in spindle motor

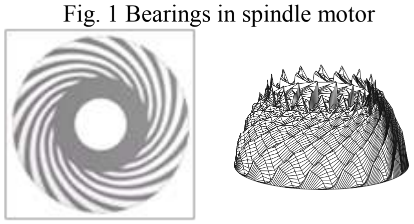

Fig. 2 Initial spiral thrust bearing groove geometry and pressure distribution