Hindawi Publishing Corporation
International Journal of Rotating Machinery
Volume 2013, Article ID 896148, 11 pages
http://dx.doi.org/10.1155/2013/896148

Research Article

Optimum Design of Oil Lubricated Thrust Bearing for Hard Disk Drive with High Speed Spindle Motor

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Received 29 July 2013; Accepted 15 October 2013

Academic Editor: Masaru Ishizuka

This paper presents the application of optimization method developed by Hashimoto to design oil lubricated thrust bearings for 2.5 inch form factor hard disk drives (HDD). The designing involves optimization of groove geometry and dimensions. Calculations are 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 stiffness 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 hydrodynamic bearings. Hydrodynamic bearing is mainly supported by thrust and journal bearings. A schematic view of bearings in a 2.5 inch HDD is shown in Figures 1 and 2.

Hydrodynamic bearing gives better performance characteristics compared to conventional ball bearings as it has high dynamic stiffness with additional much higher damping effects. These damping effect characteristics provide smaller nonrepeatable run-out (NRRO). NRRO is the major contributor to the track misregistration in HDD read-write mechanism. Even though the repeatable run-out (RRO) of oil lubricated hydrodynamic bearing 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 a spiral or a herringbone grooved geometries. Several investigators have conducted numerical analysis predictions of these grooves for HDD bearing performance [1–5]. There were also some attempts at 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 attempts at finding an optimum design with a novel geometry to replace the conventional herringbone or spiral grooves for HDD. In the attempts at improving HDD performance, Arakawa et al. [8] proposed a nonuniform spiral groove for journal bearings to expand the critical bearing number for higher revolution speed of HDD spindle. The approach indicated that the novel nonuniform spiral grooves hydrodynamic bearings manage to increase the stability of rotation in high speeds.

This suggests that there is a probability of a further improvement if the groove geometry is not being fixed to any conventional grooves, either spiral or herringbone grooves. However, as far as authors know, there are no attempts at drastically improving the bearing characteristics changing the geometry and dimensions for oil lubricated 2.5 inch HDD spindle motor. Recently, HDD is being demanded to be thinner. If the characteristic of thrust bearing can be drastically improved, it is possible for HDD to be thinner. Therefore, in this paper, by adapting the optimization method initiated by Hashimoto, 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