# Development of High Performance Multi-lobe Fluid Dynamic Bearings Using a Sintered Material

Hidekazu TOKUSHIMA

520, Minoridai, Matsudo-shi, Chiba, 270-2295 Japan
Hitachi Powdered Metals Co., Ltd.
h-tokush@hitatchi-pm.co.jp

**Abstract**

*Recently, in spindle motors for hard disk drive (HDD) devices, fluid dynamic bearings (FDB) with herringbone grooves have come to be used instead of ball bearings due to the demand for high density recording of the devices etc. In this study, a 5-lobe bearing with high bearing stiffness using a sintered material was developed, and the bearing performance was examined by simulated calculations and experiments. As a result, it was clarified that the 5-lobe bearing had the required performance for practical use in the spindle motor for HDD*

**Keywords : Sintered bearings, Fluid dynamic bearings, 5-lobe bearings, Spindle motor**

## 1. Introduction

In spindle motors for hard disk drive (HDD) devices, fluid dynamic bearings (FDB) with herringbone grooves have come to be used instead of ball bearings due to the demand for high density recording of the devices, improvement in the speed of data transfer and the quietness of the motor.

Herringbone bearings are bearings which have been prepared by creating herringbone like shaped grooves on the bearing inner surface, and which support the shaft with high accuracy using the pump like action of the herringbone grooves by rotating the shaft.

On the other hand, 3-lobe bearings are bearings which have been prepared by creating multi-lobe groove shapes on the bearing inner surface, and which have resultantly heightened the dynamic pressure action using the wedge effect of an oil film. The 3-lobe bearings are suitable in improving the speed of the motor, and are used for 30,000rpm class polygon mirror motors of laser scanners.[1)]

Two types of fluid dynamic bearings are as shown in Fig.1

About the characteristics of these FDB, Zhu and Ono[2)] evaluated the performance of herringbone bearings and the 3-lobe bearings by simulated calculations, and they clarified that the 3-lobe bearing is excellent in regards to the ratio of the bearing stiffness and bearing loss, although the herringbone bearings have higher bearing stiffness.

In this study by optimizing the bearing dimensions of the multi-lobe bearings, 5-lobe bearings have been developed with high bearing stiffness, and have been examined for practical use in the spindle motors of HDD, and compared with the characteristics of presently used herringbone bearings.

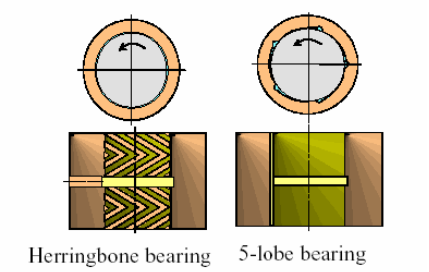


**Fig.1 Two types of fluid dynamic bearings.**

## 2. Simulated Calculations and Consideration of Multi-lobe Bearings

The optimization of the number of lobes and groove dimensions which influence the stiffness of the multi-lobe bearings by the fluid simulation software was examined. The calculations of each bearing are as shown in Table 1. There is an optimal value in the number of lobes, and it is found that bearing stiffness of a 5-lobe bearings is about 1.2 times better than that of a conventional 3-lobe bearing.

**Table 1. Calculation Conditions**

| | |
|---|---|
| I.D. of bearings | Φ3 |
| Bearing length | 2.0mm |
| Clearance | 0.004mm |
| Rotation speed | 5400rpm |
| Temperature | 25 deg. C |
| Viscosity (25 deg. C) | 18mPa-s |

Fig. 2 shows the relationship between the bearing loss and the temperature in a 5-lobe bearing and a herringbone

bearing. The bearing loss of the 5-lobe bearing is lower in value than compared with that of the herringbone bearing's. It was found that the bearing loss of the 5-lobe bearing has a low value in a low temperature especially when viscous resistance becomes large. The bearing stiffness of the 5-lobe bearing shows the same value as a herringbone bearing in a normal atmospheric environment temperature with the motor operating at around 60 deg. C. Although a herringbone bearing is superior to a 5-lobe bearing when the temperature range is less than 20 deg. C.

Fig. 3 shows the relationship between the bearing's length and the stiffness in a 5-lobe bearing and a herringbone bearing. The Bearing stiffness becomes smaller as the bearing length becomes shorter, but the 5-lobe bearing shows that the amount of decrease is smaller than that of the herringbone bearing. This suggests that a 5-lobe bearing is effective in miniaturized motors.

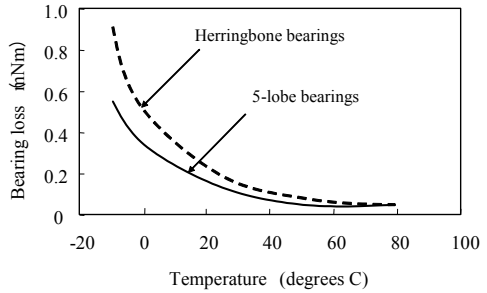


**Fig. 2 Relationship between bearing loss and temperature.**

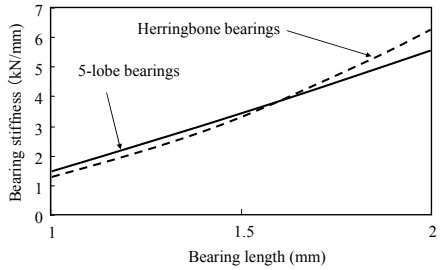


**Fig. 3 Relationship between bearing's length and stiffness.**

### 3. Bearings Tests and Results

In order to clarify the performance of the newly developed 5-lobe bearing, the characteristics were evaluated using an actual spindle motor. The test conditions are as shown in Table 2. The run current value and NRRO (Non Repeatable Run-out) was measured. In addition, in the same motor operating test, a herringbone bearing was also used for comparison. Fig. 4 shows the relationship between the temperature and the run current value in the spindle motor. In the temperature range of less than 0 degree Celsius, the reduction in bearing loss of the 5-lobe bearing clearly clarified the run current value as calculated in the results of Fig. 2. In addition, the NRRO value of the motor shows 0.02-0.04 micrometers to the demand of 0.05 micrometers and it had enough usable oscillation characteristics.

**Table 2. Bearing test condition**

| | |
|---|---|
| Bearings' dimension | Φ3.0-Φ5.2-4mm |
| Clearance | 3-4μm |
| Lubricating oil viscosity(25 deg. C) | 18mPa-s |
| Rotation speed | 5400rpm |

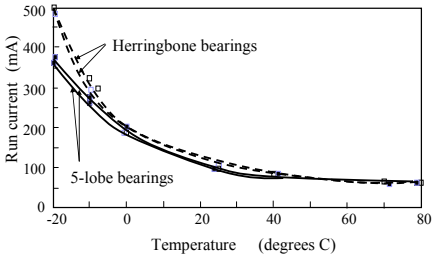


**Fig. 4 Relationship between temperature and run current.**

### 4. Summary

The following conclusions were obtained by this study.

1. The bearing loss of a 5-lobe bearing was lower than that of a herringbone bearing, and the bearing stiffness of a 5-lobe bearing was equal to that of a herringbone bearing by means of optimizing the bearings' dimensions.
2. According to the calculated results, the bearing stiffness of a 5-lobe bearing is bigger than that of a herringbone bearing when the bearing's length is less than 1.5 mm, and a 5-lobe bearing shows clearly that it is effective in miniaturized motors.
3. It was found that the run current of the spindle motor using a 5-lobe bearing is lower in value than compared with that of a herringbone bearing when the temperature is less than 0 degree Celsius. In addition, the NRRO value of the motor shows 0.02-0.04 micrometers to the demand of 0.05 micrometers, and resultantly has been clarified for its practical use.

### 5. References

1. Hidekazu Tokushima, Motohiro Miyasaka, Katsutoshi Ni: Development of a Sintered bearing with Inner Grooves, Proceedings of the 2002 World Congress on Powder Metallurgy & Particulate Material, and part (2002) 2 95-102
2. Jiasheng Zhu, Kyosuke Ono: Characteristic Comparison Study of on Characteristics of Four Type of Hydrodynamic Oil bearings for Hard Disk Spindles, Japan Society of Mechanical Engineers collected-papers (C) 64,622 (1998-6) 33