Low Particle-Emission Grease for HDD Spindle Bearings

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Hard disk drives are rapidly increasing in their application for high speed, high capacity external recording apparatuses. In 1998, the amount of production of hard disk drives reached about 140 millions, and it is estimated that the production of hard disk drives will increase over ten percents per year.

Higher capacity and down-sizing are technical trends of hard disk drives, so it is likely that ferrofludic seals will be abolished. In this case, cleanliness and particle-emission performance of bearings become very important. This paper describes KHD grease which has low particle-emission, low torque, and low vibration properties.

***Key Words**: particle emission, hard disk drive, spindle bearing, grease*

1. Introduction

Applications for Hard Disk Drive (hereinafter referred to as HDD) are rapidly increasing as high speed, high capacity external recorders, for example, large computers, personal computers, facsimile machines and copiers. The number of units producted in 1998 was approximately 140 millions. Though the growth rate at the year of 9.3% was the lowest rate over the past several years, it is estimated that the growth rate of over ten percents per year will be kept[1].

There is also a move toward more compact HDD by abolishing ferrofludic seals. In order to achieve this, particle emission from bearings will have to be controlled by using low particle-emission grease. This paper reports on the newly developed KHD grease which has low particle-emission, low torque and low vibration properties for HDD spindle bearings.

2. Required Performance

2. 1 Performance Required for HDD Spindle Bearings

Small diameter ball bearings of standard dimension are generally used for HDD spindle application. An example is shown in **Fig. 1**. As HDDs become more compact and thinner, narrow width type bearings are also increasingly used.

The followings are given as technical trends of HDDs[2].

①Larger capacity
②More compact size
③High speed
④Power saving
⑤Improved quietness

The performance required for HDD spindle bearings to satisfy these trends is given in **Table 1**.

In order to increase capacity, higher recording density is required. Track density is currently about 2μm/inch. If this becomes 1μm/inch, the 0.02μm～0.03μm NRRO (non repeatable runout) of bearing causes a data read/write error[3]. For this reason, NRRO accuracy improvement of bearings is imperative for increasing capacity of HDDs.

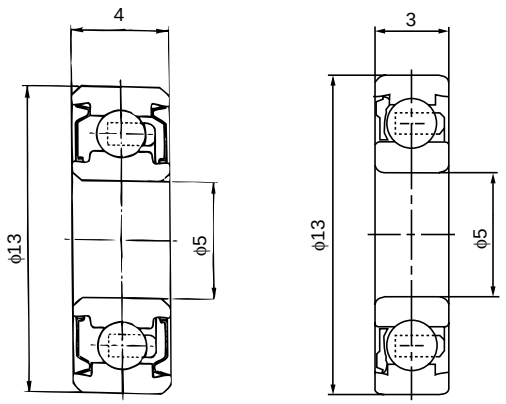

Fig. 1 Cross section of ball bearings for HDD spindle motor

Table 1 Required performance for HDD bearings and greases

	HDD trend	Bearing performance	Grease performance
1	Larger capacity	Low NRRO, low particle-emission	Low particle-emission
2	More compact size (in case of abolition of ferrofluidic seal)	Low particle-emission, narrow width	Low particle-emission
3	Low power consumption	Low torque	Low torque
4	Quietness	Low noise, low vibration	Low noise
5	Long life	Long life	Long life
6	Others (cost, out-gas, etc.)	Low cost Low out-gas, etc.	Low cost Low out-gas, etc.

Also, the distance between the head and disk (Flying height: hereinafter referred to as FH) must be reduced to get increased capacity. FH is currently about 0.1μm～0.5μm, but 0.025μm FHs are beginning to be used[1]. If particle contaminants from rolling bearing adhere to the disk surface,

data read/write errors will occur as well as head crash that makes rotation impossible. For this reason, performance such as no contamination of oil on the surface and as little splattering oil as possible during rotation is required of the bearing.

Contamination on the disk surface by particles splattered from the bearing is currently prevented by ferrofludic seals. However, in order to make the HDD more compact, there is a movement to abolish ferrofludic seals. For this reason, cleanliness and low particle-emission are more important for HDD bearings.

In addition, performance such as low torque for energy saving, low noise, and low vibration are required for HDD bearings.

2. 2 Performance Required for HDD Bearing Greases

Required performance for HDD bearing grease is given in **Table 1**.

Generally, low torque, low noise and long life are required for motor bearing greases. Furthermore, low particle-emission performance is required for HDD bearing greases in order to prevent head crash if ferrofluic seals will be abolished to achieve the compact size. Fluorocarbon greases used for bearings for semiconductor manufacturing equipment are generally used as low particle-emission greases. Such grease has been developed and used at Koyo since 1990. However, the properties required for bearings for semiconductor manufacturing equipment differs from those for HDD spindle bearings. For this reason, a grease suitable for HDD spindle bearings was developed.

3. Composition and Performance of Low Particle-Emission KHD Grease

3. 1 Composition and Properties of KHD Grease

Composition and properties of KHD grease are given in **Table 2**. As a comparison, the table also gives the composition and properties of conventional grease A and B which are used for HDD application.

Table 2 Composition and properties of KHD grease

	KHD	Grease A	Grease B
Thickener	Li-soap	Li-soap	Na-soap
Base oil	Poly α olefin	Ester	Mineral oil
Base oil kinematic viscosity, mm^2/s (@40°C)	25	26	109
Worked penetration, 60W	181	250	205
Dropping point, °C	203	192	Min. 260
Evaporation loss, wt% (99°C × 22h)	0.14	0.30	1.0
Oil separation, wt% (100°C × 24h)	0.1	1.2	0.2
Oxidation stability, MPa (99°C × 100h)	0.015	0.025	0.07

Li-soap was selected as a thickener. This is because it is easy to obtain good acoustic characteristics of bearing, and because the operating temperature in which the HDD is used is about maximum 80℃. Considering grease life, poly α olefin with its superior heat resistance was used as a base oil, and considering torque characteristics, oil viscosity of $25mm^2/s$ at 40℃ was selected. Also, it has been confirmed that the amount of particle emission is not largely influenced, even if base oil viscosity is low.

Also, as it was confirmed that particle emission is high for soft grease with a small NLGI penetration number, particle emission is low for hard grease, and particle emission tends to more or less saturate with NLGI penetration no. 3 or 4 grease. So no. 4 penetration was selected.

3. 2 Grease Performance

3. 2. 1 Particle-Emission Performance

The amount of particle emission was measured using the equipment as shown in **Fig. 2**, with 10mg grease packed deep groove ball bearings of inner diameter 5mm and outer diameter 13mm. Rotation speed was 5 $400min^{-1}$ by outer ring rotation. The particles from the bearing were sucked in and particles of diameter 0.1μm or more in 2.83 l (= 0.1 ft^3) were counted by a light scattering type particle counter.

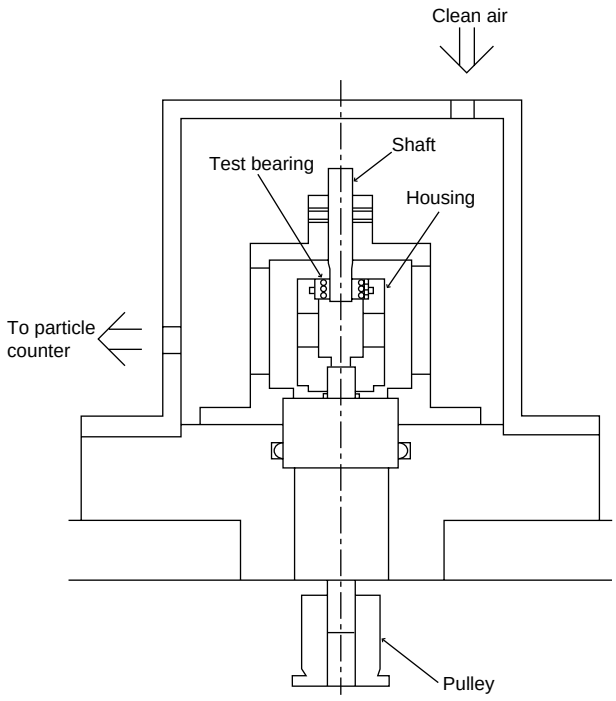

Fig. 2 Measuring equipment for particle-emission

Particle-emission performance of KHD grease is shown in **Fig. 3**. The amount of particle-emission of KHD grease is approximately 1/5 of that of grease A, showing good particle-emission performance. However, it did not reach the level of grease B. The reason for this is considered to be the effect of the composition of thickener type and the length of its fibers, etc.

3. 2. 2 Acoustic Performance

Acoustic performance was evaluated by the vibration value which has a good correlation with acoustic performance. Deep groove ball bearings of inner diameter 5mm and outer diameter 13mm were packed with 10mg grease, and vibration value of the inner ring was measured at rotation speed of 1 800min^{-1} by outer ring rotation with a pre-load of 5.4N.

Acoustic performance of KHD grease is shown in **Fig. 4**. KHD grease shows good acoustic performance equal to or better than grease A. Compared with grease B, the vibration value was about the 1/2 level. Also, the sound of thickener being crushed was not noticed, and tone quality was good during test.

3. 2. 3 Torque Performance

Rotation torque was measured with deep groove ball bearings of inner diameter 5mm and outer diameter 13mm packed with 10mg grease with a pre-load of 11.8N at rotation speed of 5 400min^{-1} by outer ring rotation.

Torque performance of KHD grease is shown in **Fig. 5**. The rotation torque of KHD grease was approximately 15% less than that of grease A, and approximately 30% less than that of grease B, and was the most superior for torque performance.

4. Conclusion

KHD grease developed for HDD spindle bearings has superior low particle-emission, low torque and acoustic characteristics compared with conventional greases. Furthermore, KHD grease is also applicable for bearings other than for HDD application, requiring low particle-emission characteristics at ordinary temperature and normal pressure.

References

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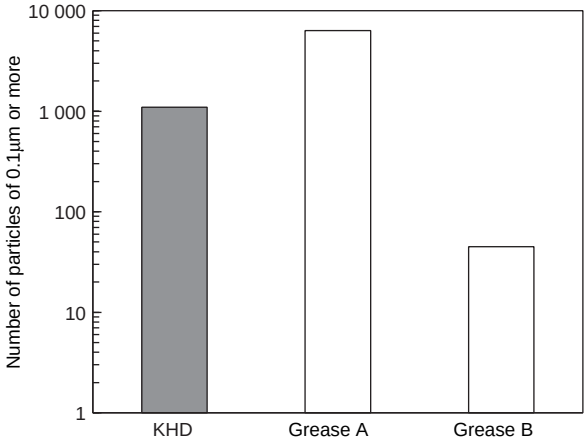

Fig. 3 Particle measurement

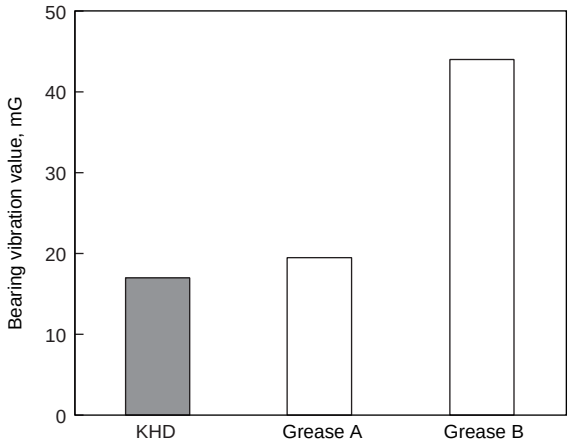

Fig. 4 Acoustic performance

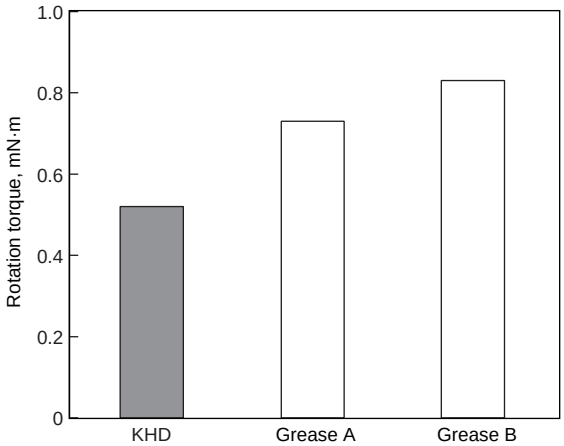

Fig. 5 Torque performance