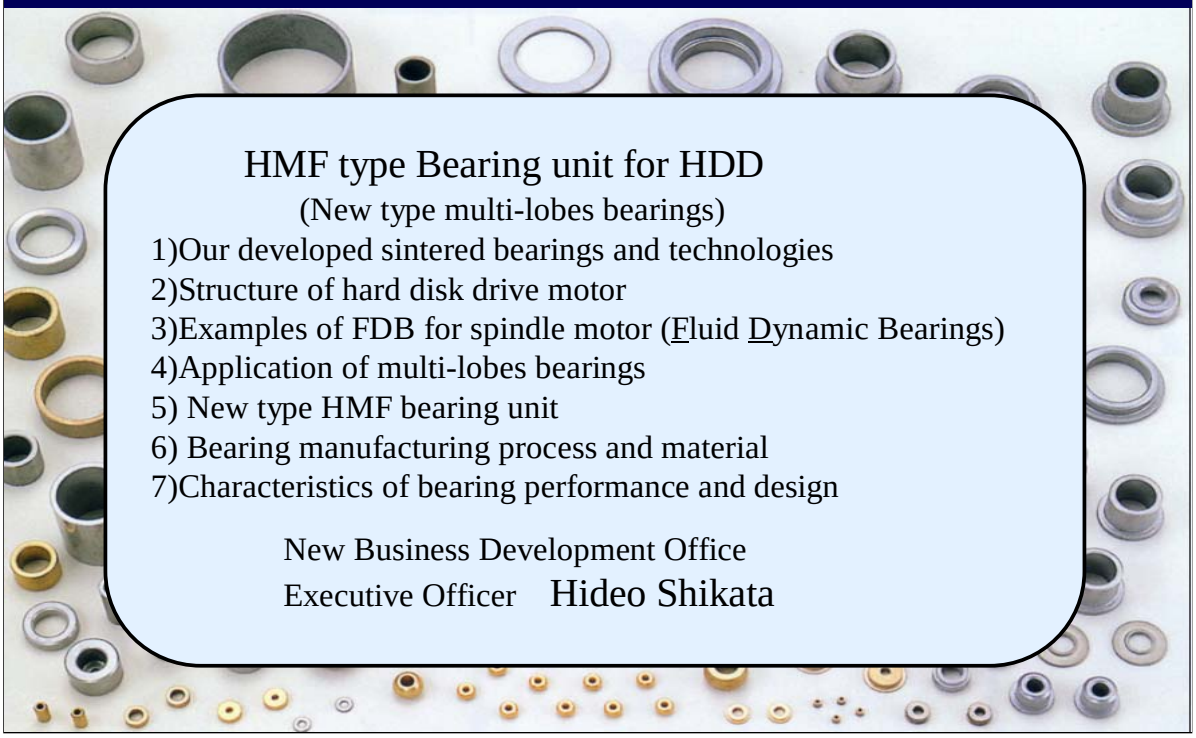
Hitachi Powdered Metals Co., Ltd.

HITACHI
Inspire the Next



HMF type Bearing unit for HDD

(New type multi-lobes bearings)

1)Our developed sintered bearings and technologies
2)Structure of hard disk drive motor
3)Examples of FDB for spindle motor (Fluid Dynamic Bearings)
4)Application of multi-lobes bearings
5) New type HMF bearing unit
6) Bearing manufacturing process and material
7)Characteristics of bearing performance and design

New Business Development Office
Executive Officer Hideo Shikata

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Sintered products (Machine parts)

For transportation machines, For vehicles transmission parts
For vehicles parts, Vehicles parts for auxiliary units,
For motor cycles, Industrial machines
For industrial machine parts for

- general- purpose engine
- general- purpose engine
- agricultural machines
- construction machinery
- hydraulic equipment

I would like to begin by providing you with a brief overview of our operations. Our sintered products consist primarily of machine parts and bearings. Approximately 85% of our machine parts are for the automotive industry.

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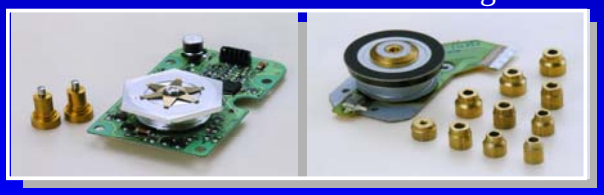
Sintered products (Bearings)

For motors, For home applications, For audio equipment, For construction machines

For motors

Special shape bearings

For construction machinery



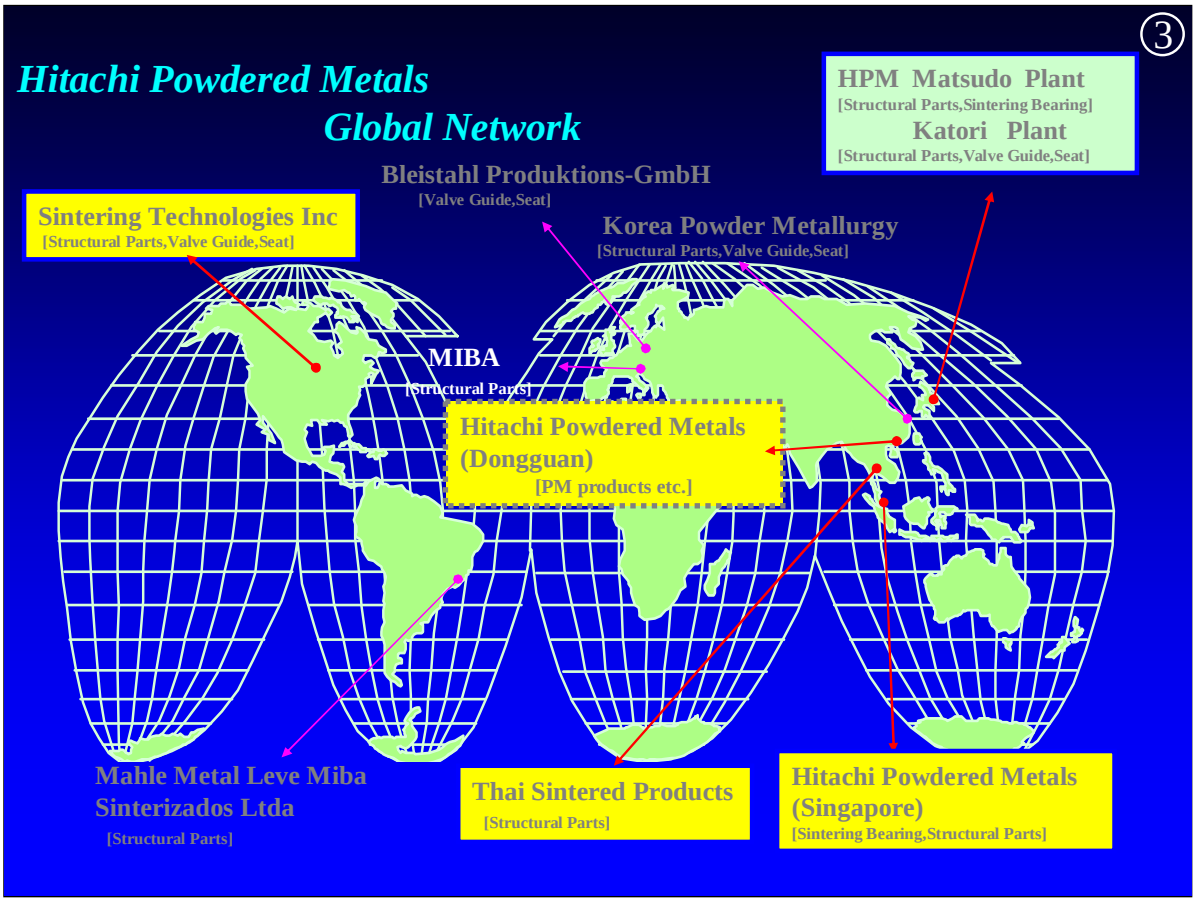
Polygon mirror motor

Spindle motors for compact disk

Spindle motor for HDD

We developed precise manufacturing technology and bearing materials.
Apply to hard disk motors.

Our other mainline business, bearings, supplies the automotive, construction, office equipment and consumer appliance industries, among others. About 15 years ago we entered the market for the bearings used in polygon mirror motors and spindle motors for compact disks. This enabled us to develop the technologies for precision forming and manufacturing and for long-life bearing materials, which we were then able to apply in spindle motors for hard disk drives.



I would now like to describe our global network. We have two plants in Japan, and one each in the USA, Thailand and Singapore. We have also decided to begin operations in Dongguang, China. In addition to this, we have many technical alliances around the world that round out our global supply system.

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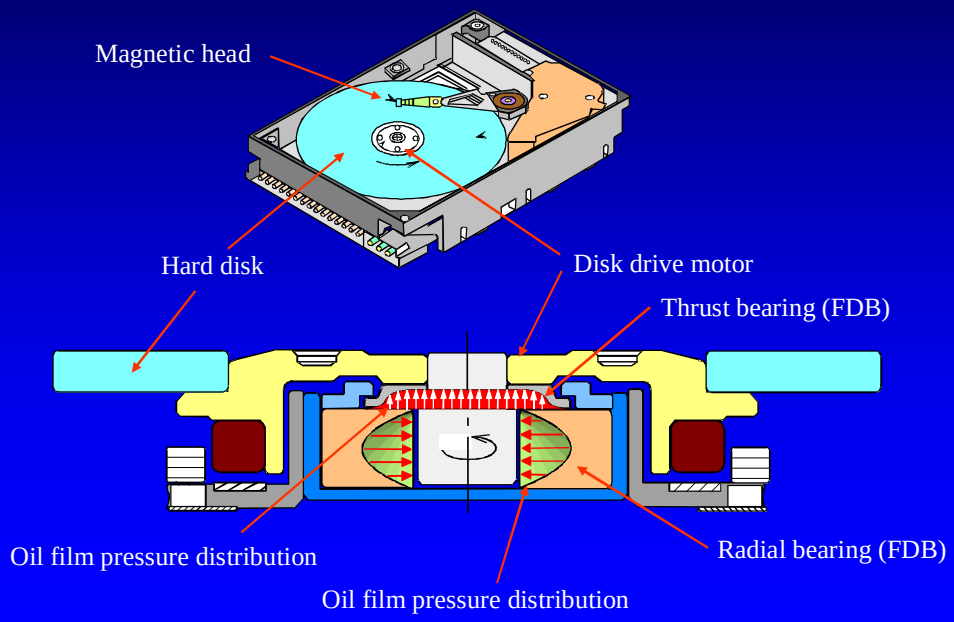
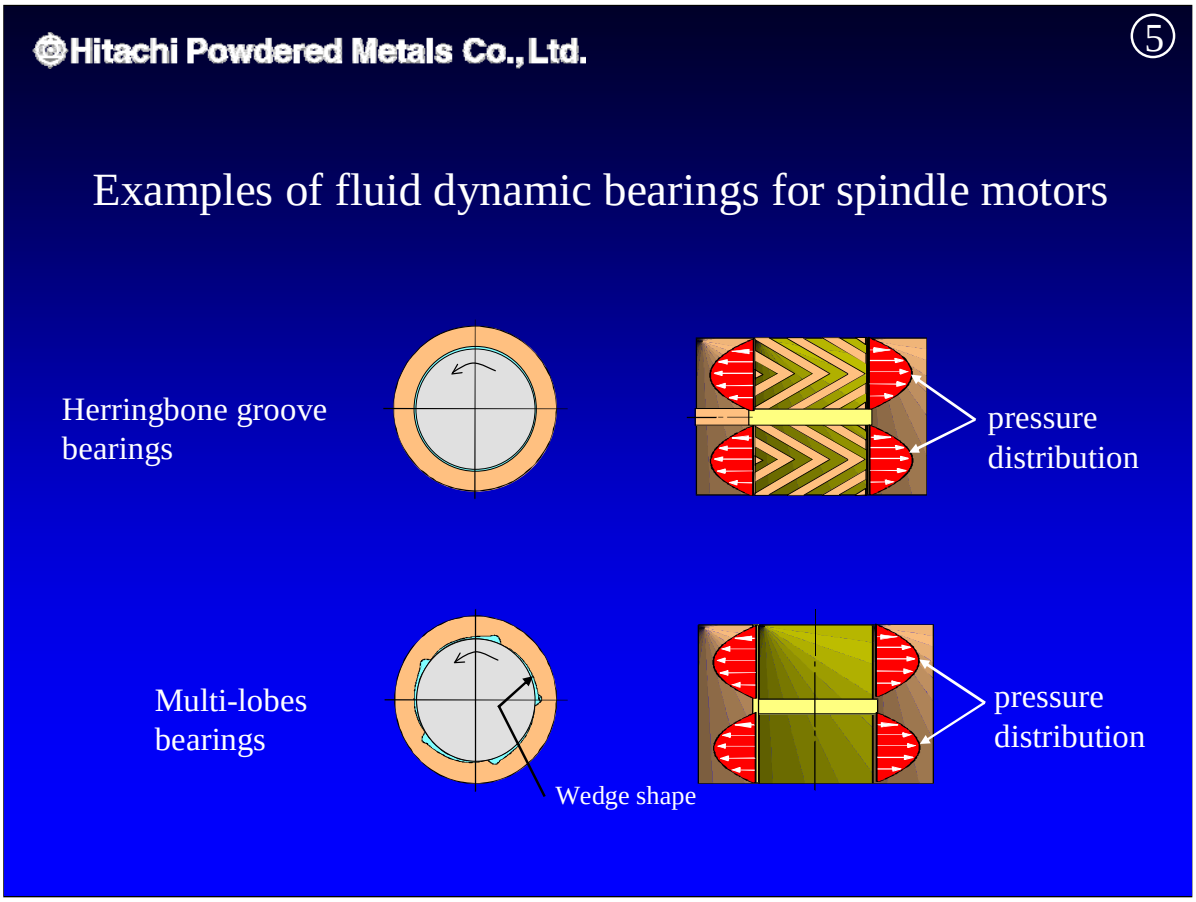
Structure of hard disk drive motor

(Disk supporting mechanism by FDB)



We recently announced a new HMF type fluid dynamic bearing (FDB) unit structured so that the dynamic pressure is generated on the inner surface and the upper thrust surface of the bearing. On the radial side, oil film pressure supports the shaft. On the thrust surface, oil film pressure in the upwards direction lifts up the entire thrust surface and causes it to slide.



The most common FDBs used in HDD spindle motors today are what is known as the "herring bone type." As the name suggests, these bearings have grooves along the inside diameter of the bearing that are shaped like herring bones. By contrast, multi-lobe FDB have an array of evenly-spaced arcs ("lobes") running vertically along the inner diameter, with the wedging of the oil in the bearing openings generating dynamic pressure that produces stable revolution.

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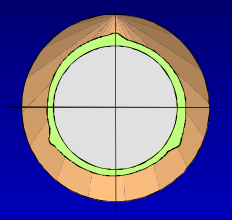
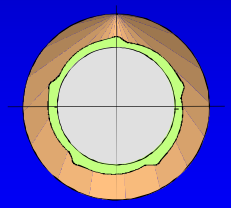
Application of multi-lobes bearings
(Three lobes bearings and five lobes bearings)



1) Polygon mirror motor for digital full color printer

2) Disk drive motor for optical disk equipment
(CD-ROM, DVD-ROM)

3 lobes bearings



3) Disk drive motor for Magnetic disk equipment

5 lobes bearings

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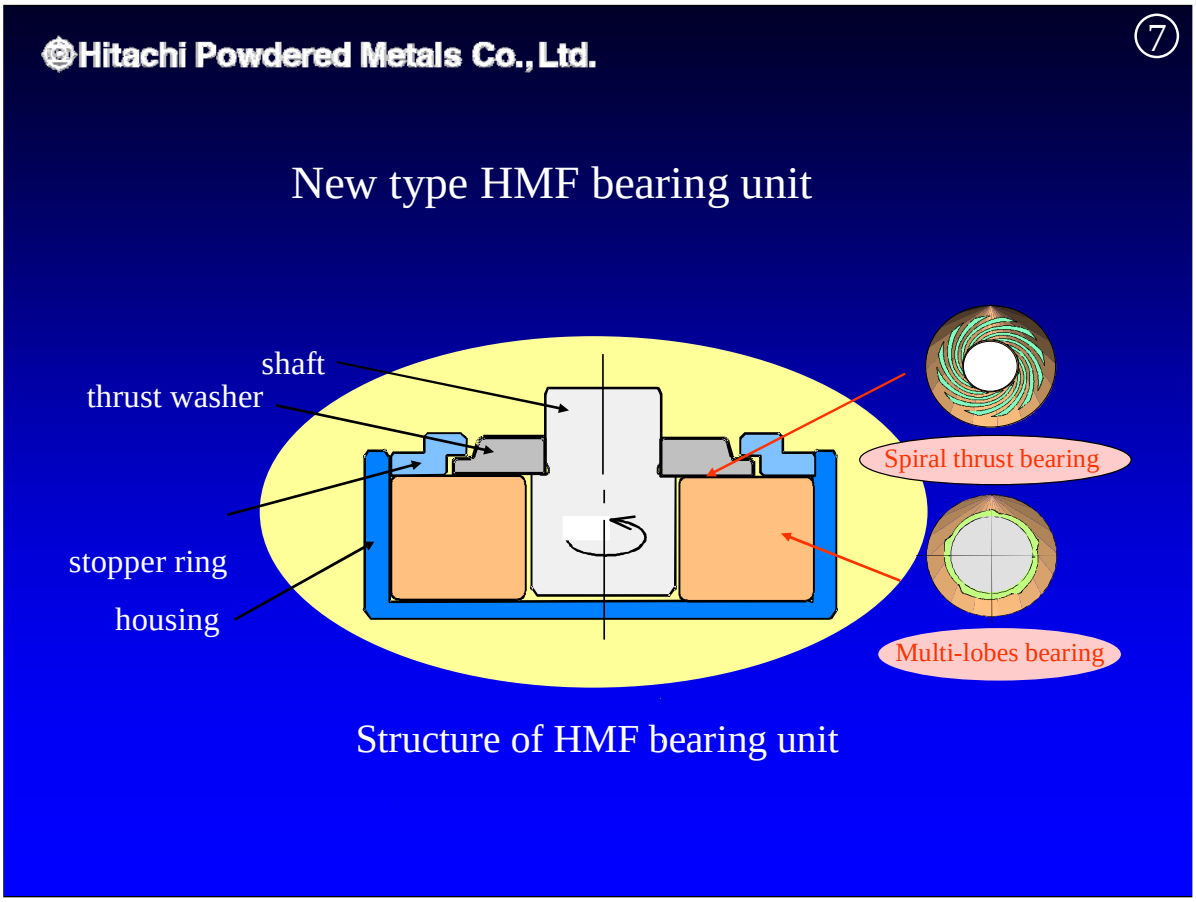
Three-lobe bearings are suited to high-speed, high-precision revolutions and are used in laser scanner motors and optical disc drive motors, among other applications. For the ultra-precise revolutions required by HDD spindle motors, we have developed five-lobe bearings (HMF). I will now explain about this bearing technology.



We collaborated with Minebea on the development of HMF type FDB units. The name comes from the initials of the two companies. We provide the bearing portion; Minebea assembles the bearing unit. The inside of the bearing portion is formed with multiple lobes. The thrust face has spiral dynamic pressure grooves for the bearing.

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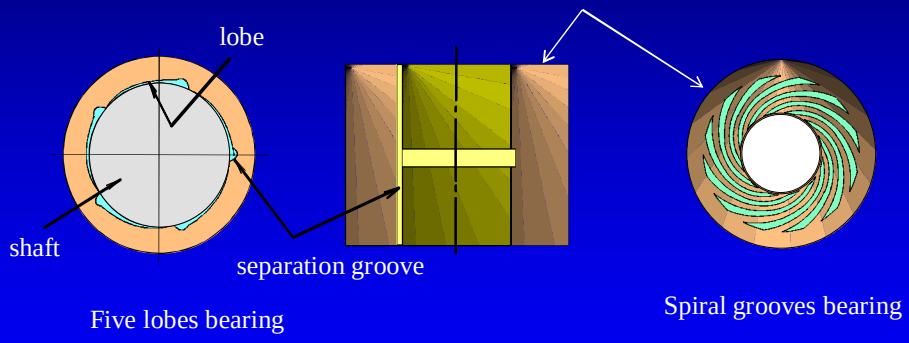
HMF type fluid dynamic bearings



For HMF FDBs, the five lobes on the radial bearing portion and the spiral grooves on the thrust face are formed simultaneously ("sizing") so that a single bearing can take the radial and thrust load. We developed the unique sintering technologies and sizing processes that make it possible to form the radial and thrust bearings as a single unit. Compared to conventional herring bone bearings, these technologies make it easier to mold the shape of the radial bearing and enable the achievement of a radial bearing thickness as thin as 1 mm.

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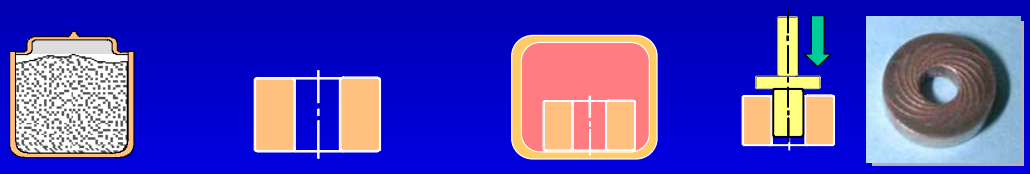
Bearing manufacturing process and material

1) Manufacturing process

Mixing → Compacting → Sintering → Sizing



2）Material

- Nikkaloy EAK-3: Cu(50~55%), Sn(1~3%), Fe(Rem)

The manufacturing process begins by mixing the powder. We then use a metal mold to press-form the powder. This is followed by sintering to encourage metal bonding. Finally, the sizing process simultaneously forms the multiple lobes on the inside of the bearing and the spiral dynamic pressure on the tip. The result is extremely high-productivity and low-cost production.

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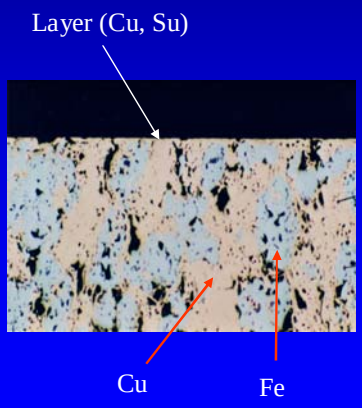
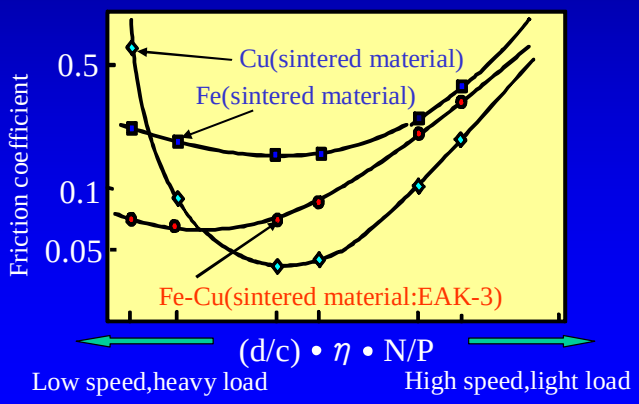
Nikkaloy EAK-3

EAK-3 is an excellent material in lubricity and were resistance.

Fe	Cu	Sn	P	C	-
Rem	50~55	1~3	0.1~0.5	<1.0	<0.5

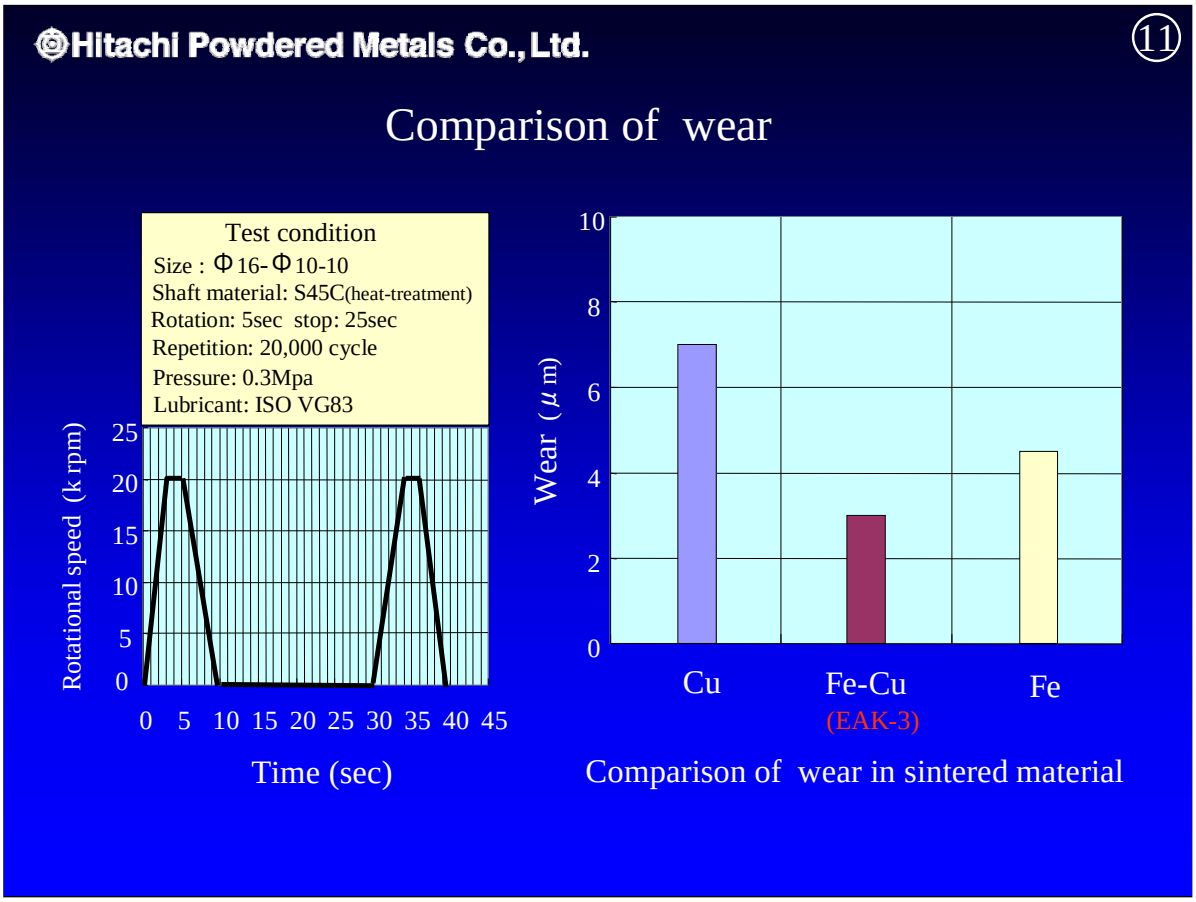


Micro structure



Friction characteristics of various sintered materials

As sintering material we use our own Nikkaloy EAK-3. Nikkaloy EAK-3 features excellent lubricity and formability because it is roughly half copper and half iron. A special production method gives it a bronze layer on the surface. This sintering material combines the lubricity of copper with the friction resistance of iron to maintain a low friction coefficient even under low-speed/heavy-load conditions or repeated ON/OFF operations. In other words, it results in bearings with excellent friction resistance and sliding properties.



As one example, this data shows Nikkaloy EAK-3's friction resistance under repeated ON/OFF operations.

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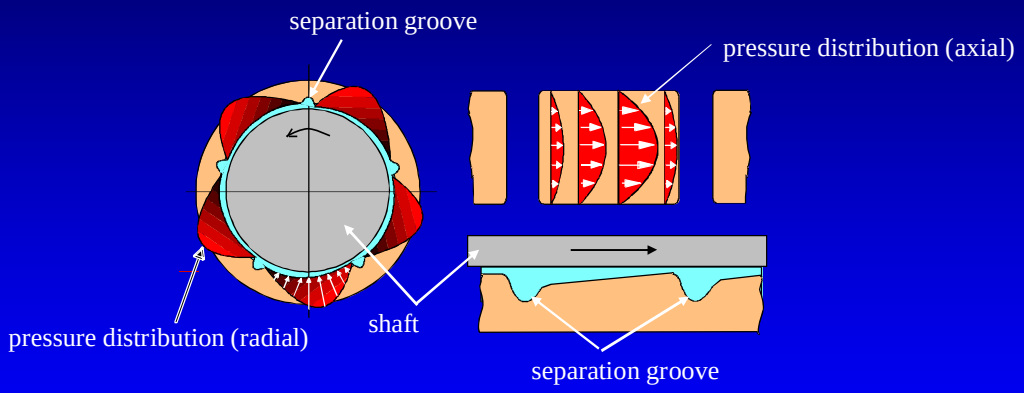
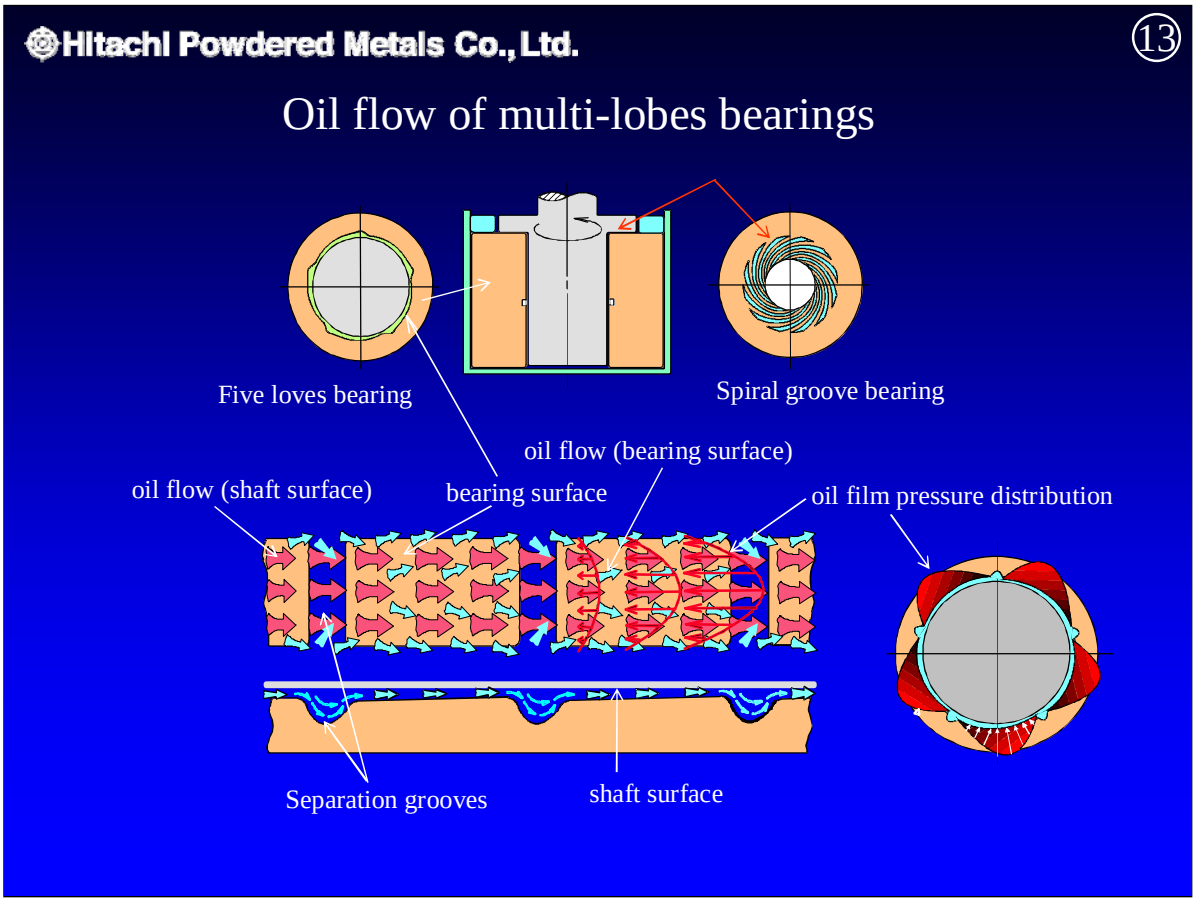
Dynamic pressure generation mechanism of multi-lobes bearings



The dynamic pressure of a multi-lobes bearings generates by the wedge action of the oil in the bearing clearance. The shaft is supported in high accuracy rotation by fluid dynamic pressure.

In multi-lobe bearings, when the shaft rotates counter-clockwise the wedge openings gradually narrow to generate the dynamic pressure. Then they open at the separation groove, and the next dynamic pressure is generated.



This development drawing of the inside of the bearing illustrates the oil flow. The blue arrows indicate the oil flow on the bearing surface; the red arrows also indicate the oil flow on the shaft surface. The shaft surface oil flows in evenly. The cross-section below shows how the oil temporarily builds up in the separation groove before flowing again.

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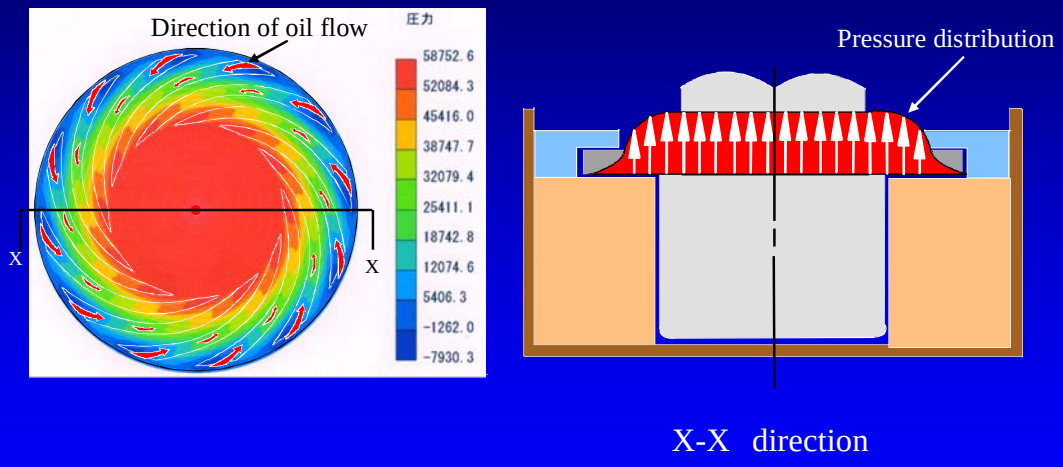
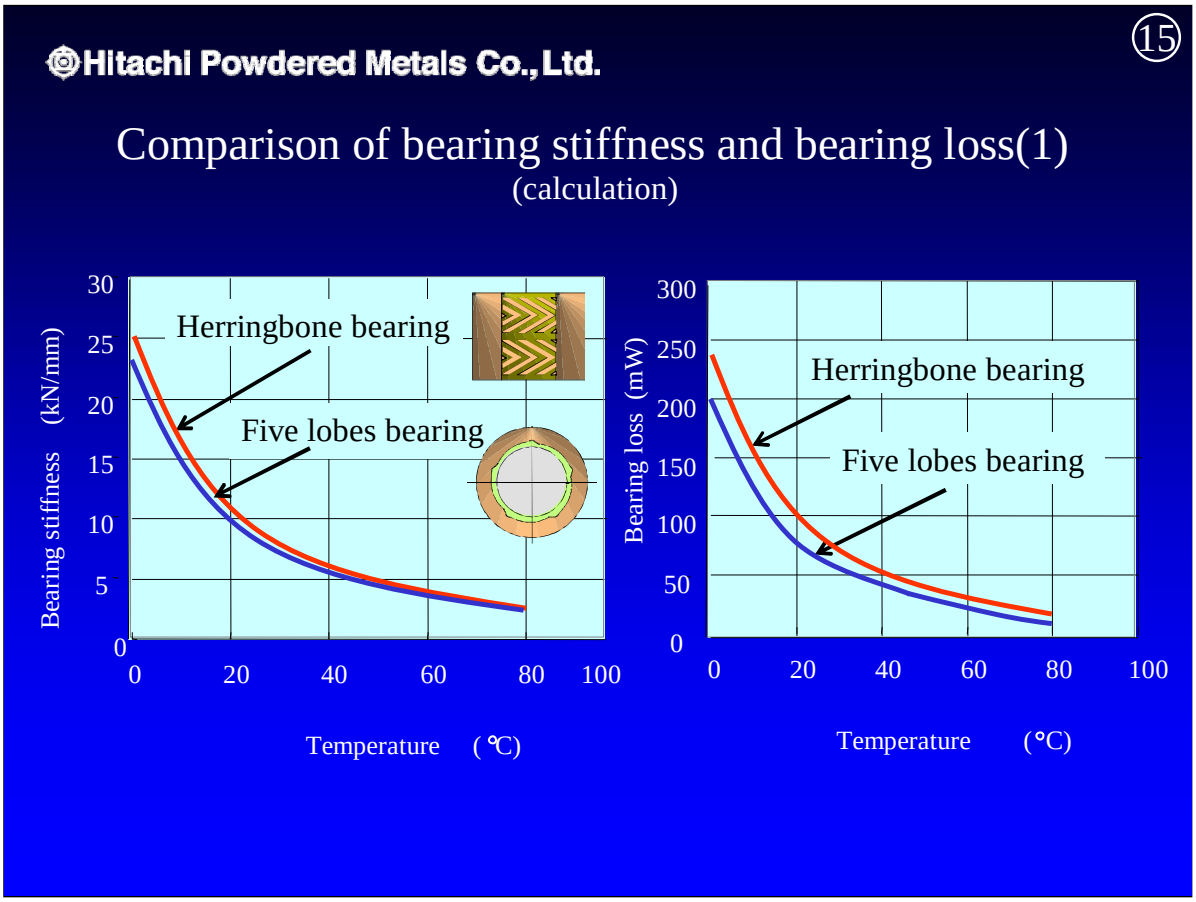
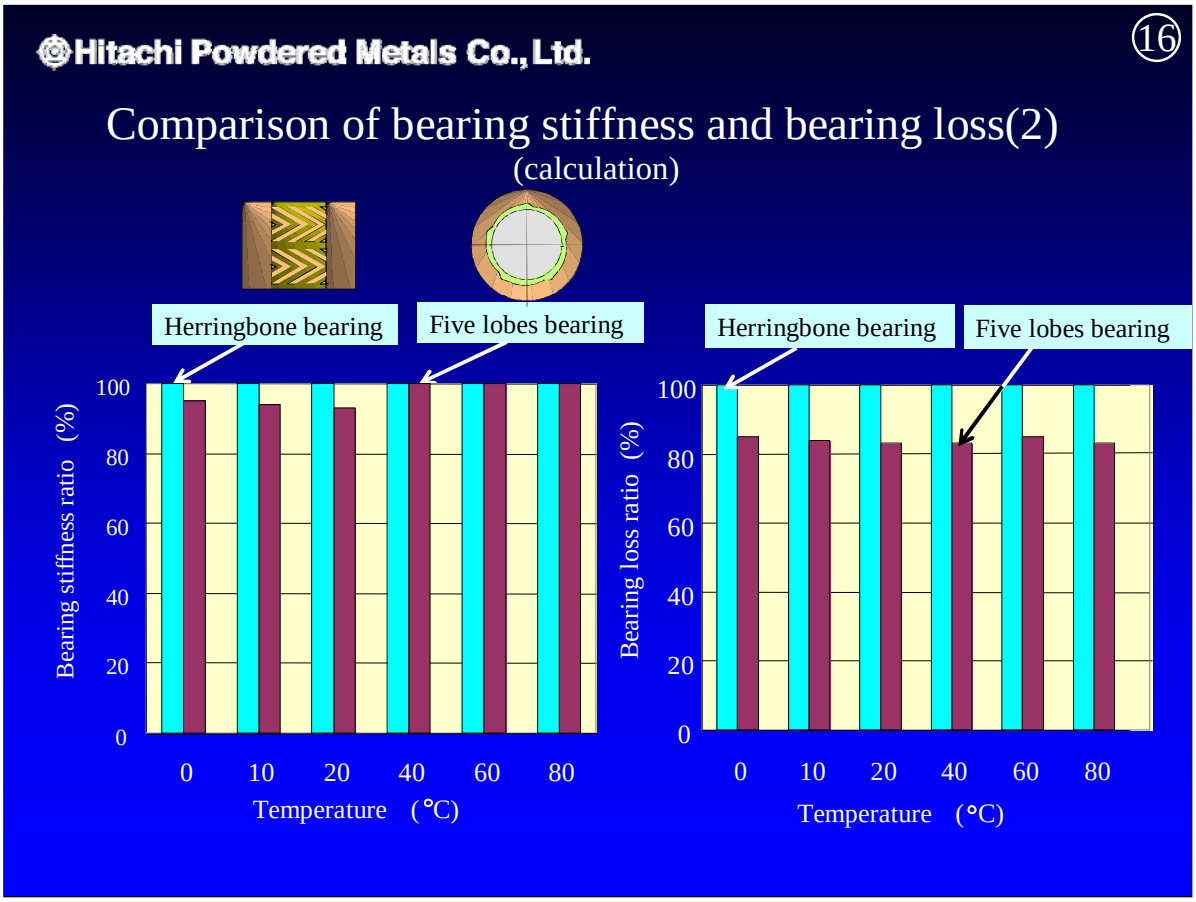
Oil flow and pressure distribution of spiral groove bearings



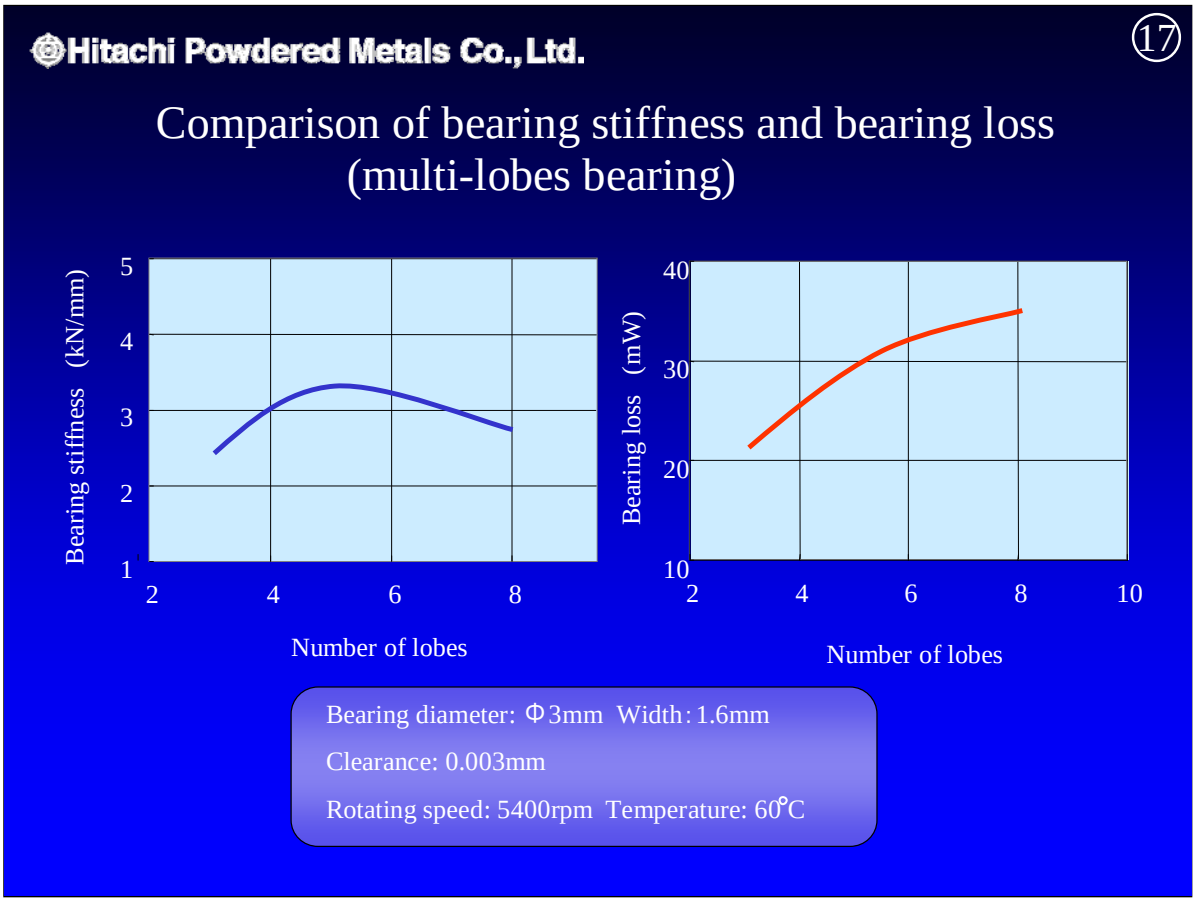
This figure shows the oil flow and dynamic pressure distribution for spiral thrust bearings. In the figure on the left, the oil pressure is shown in color code (the closer to red, the higher the pressure). The red arrows indicate oil flow. The thrust washers cause the oil to flow inwards along the groove so that the pressure on the center reaches its highest point. The figure on the right shows this from a side perspective. The shaft rises because the dynamic pressure is generated evenly on the thrust surface.



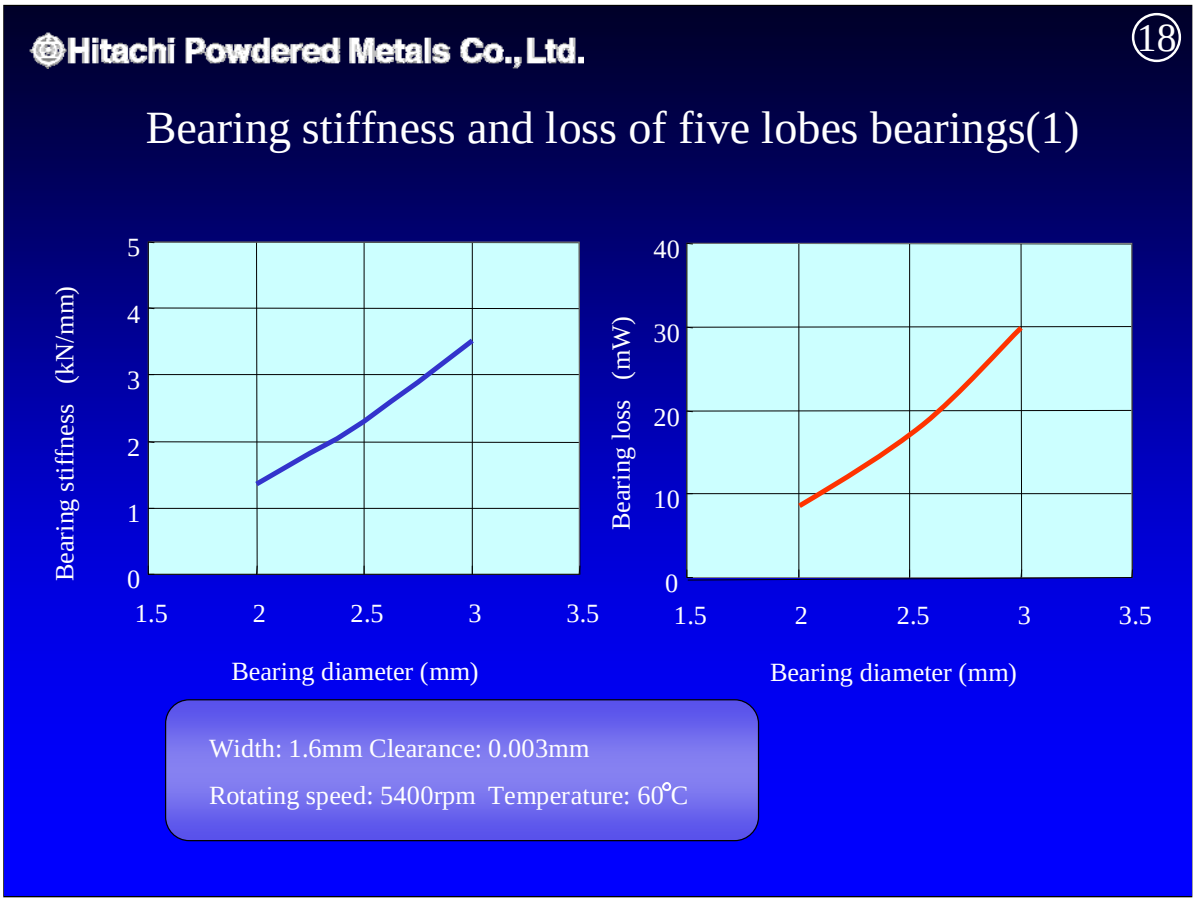
Le me explain about the performance of the HMF type FDBs. I'd like to begin by comparing the bearing stiffness and the bearing loss of conventional herring bone bearings and five-lobe bearings. The vertical axis of bearing stiffness shows the force supporting the shaft; the vertical axis of bearing loss, the resistance on the bearing. The higher the numbers, the stronger the force or resistance. There is almost no difference between five-lobe bearings and herring bone bearings in terms of bearing stiffness, but for bearing loss the five-lobe bearing has much less resistance, especially at lower temperatures.



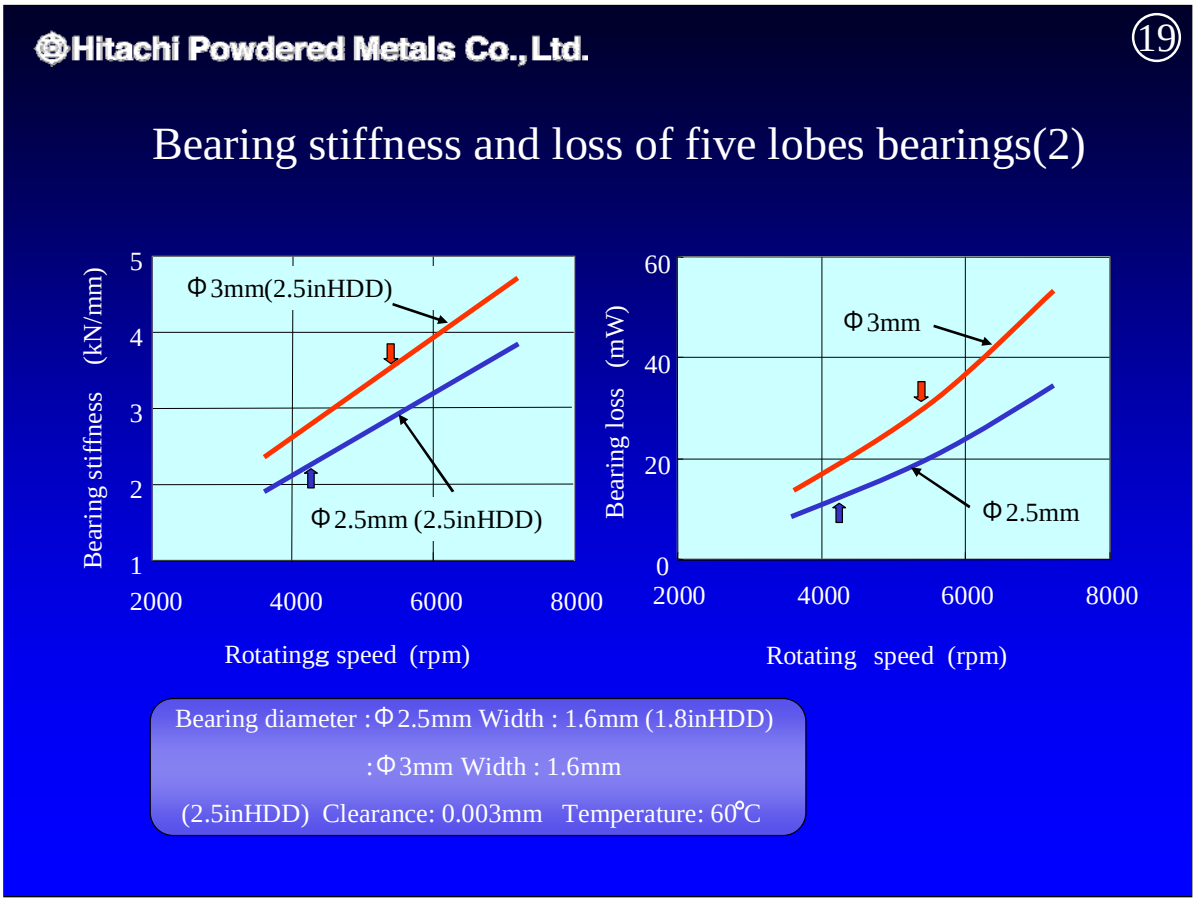
This figure compares bearing stiffness and bearing loss from the previous slide, expressing the relationship as a percentage. Bearing stiffness does not show any substantial change at different temperatures, but for bearing loss the figures for five-lobe bearings are close to 20% lower at all temperatures.



This data indicates the optimum number of lobes. Five lobes have the best bearing stiffness; as the number of lobes increases, the bearing resistance rises.



Bearing stiffness and bearing loss change according to the diameter of the bearing (shaft diameter). The smaller the shaft diameter, the lower the bearing stiffness, but the lower the bearing loss as well.



This figure provides a comparison under different RPM conditions. The red line shows the 3-mm shaft diameter used in 2.5-inch HDD spindle motors; the blue line, a 2.5-mm shaft for 1.8-inch HDDs. Optimum bearing stiffness and bearing loss values enable five-lobe bearings to be fully suitable for HDD spindle motors.

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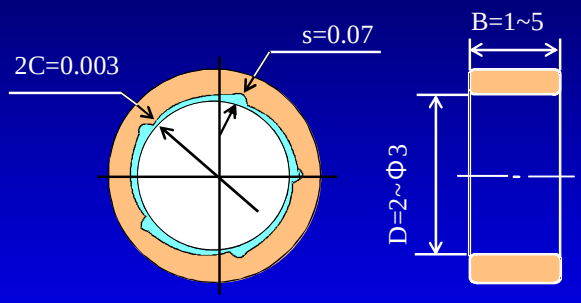
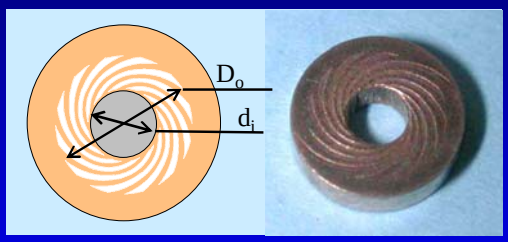
Application of multi-lobes bearings for HDD



Radial bearings
2.5in HDD:D=Φ3 mm B=4.8 mm
1.8in HDD:D=Φ2.5 mm B=2 mm



Thrust bearings
2.5in HDD: D_o =Φ5 mm d_i=3 mm
1.8in HDD: D_o =Φ4.5 mm d_i=2.5 mm

The bearing is designed with a minimum clearance of 3 microns, separation groove of 70 microns and bearing width of 1-5 mm.

Conclusions

Features of our developed bearing technologies are as follows.

1) 5 lobes bearings :

High bearing stiffness and low bearing loss.

2) HMF bearing unit:

The best for downsizing of HDD

3) Our developed precise manufacturing technology and bearing materials:

50% or less of conventional cost

To summarize, the multi-lobe type FDB has three main features. Its bearing properties are equivalent or better than conventional herring bone FDBs, it is suited to downsized HDD spindle motors, and it enables significant cost savings.