Award Winning Products

2020"CHO" MONODZUKURI Innovative Parts and Components Award, Mobility Components Award

Low Friction HUB Bearing Ⅲ

Makoto SEKI

1. Introduction

The "Low Friction HUB Bearing Ⅲ"[1], which reduces rotational friction while driving by 62 % compared with conventional products, received the 2020 "CHO" MONODZUKURI Innovative Parts and Components Award, Mobility Components Award sponsored by MONODZUKURI. Nippon. Conference and Nikkan Kogyo Shimbun, Ltd.

NTN developed bearing internal grease in pursuit of low friction, and combined with the latest low friction seals, was able to reduce rotational friction by 62 % when compared with conventional products[2]. Using this product on the wheels at both sides of a vehicle is expected to improve vehicle fuel efficiency by approximately 0.53 %.

2. Structure

Fig. 1 shows a schematic drawing of Low Friction HUB Bearing Ⅲ.

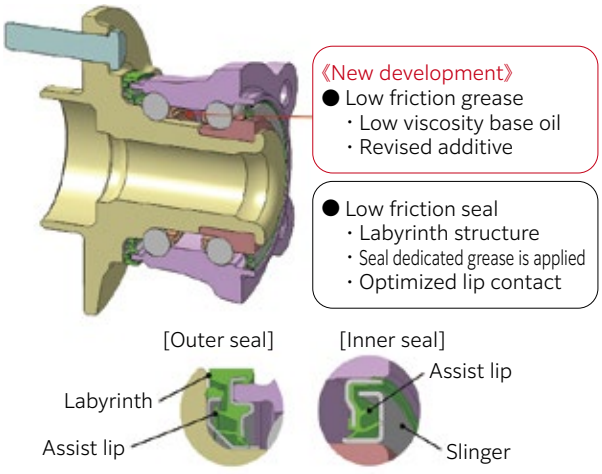

Fig. 1 Structure of Low Friction HUB Bearing Ⅲ

3. Features

The following are the features of Low Friction HUB Bearing Ⅲ.

(1) Application of newly developed low friction grease
(2) Application of new seal structure with labyrinth
(3) Application of seal dedicated grease
(4) Optimization of seal lip contact surface

As shown in **Fig. 2**, these features reduce bearing friction and outer/inner seal friction to achieve a running torque reduction of 62 % for the entire hub bearing.

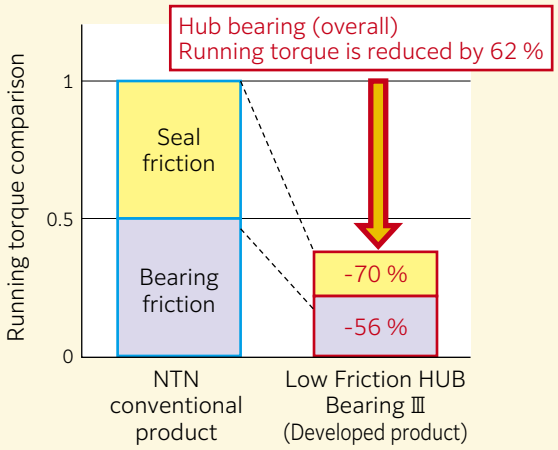

Fig. 2 Hub bearing running torque comparison (an example)

4. Summary

To support stricter emission regulations on CO_2 and improve vehicle fuel efficiency throughout the world, **NTN** has developed a hub bearing with significantly lower friction over conventional products while meeting the requirements for service life and strength. **NTN** will continue to develop the market for this product, which is expected to improve vehicle fuel and power consumption efficiency, and also contribute towards reducing the impact on the global environment.

References

1) Makoto Seki, Low Friction HUB Bearing Ⅲ, NTN TECHNICAL REVIEW, No.87, (2019) 63-67.
2) Makoto Seki, Low Friction HUB Bearing, NTN TECHNICAL REVIEW, No.85, (2017) 67-71.

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Award Winning Products

Nippon Brand Award of 2021 “CHO” MONODZUKURI Innovative Parts and Components Award

High Speed Deep Groove Ball Bearing for EV/HEV

Goro NAKAO Katsuaki SASAKI Yukihiro ISHIDA Kazunori MURANUSHI

1. Introduction

NTN’s “High Speed Deep Groove Ball Bearing for EV/HEV”[1], has achieved the world’s highest level of allowable speed by the Nippon Brand Award of 2021 “CHO” MONODZUKURI Innovative Parts and Components Award sponsored by MONODZUKURI. Nippon. Conference and Nikkan Kogyo Shimbun, Ltd.

This product was developed using technology that optimizes the shape and material of the bearing cage to minimize the energy lost due to friction. As motors become smaller and faster to accommodate the continued electrification of the industry, there is a growing need for bearings that can support high-speed rotation of 1.8 million $d_m n$[*1].

Furthermore, with the aim of improving performance of deep groove ball bearings, high regard is placed on such things as the creativity of designers and development concepts that provide verification of results after planning detailed improvements.

2. Structure

Fig. 1 shows a schematic drawing of a cage for the High Speed Deep Groove Ball Bearing for EV/HEV.

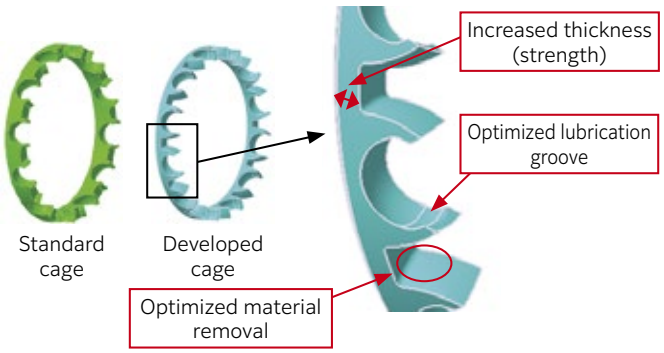

Fig. 1 Structure of developed cage

3. Features

NTN’s “High Speed Deep Groove Ball Bearing for EV/HEV” contains the following features:

(1) The world’s highest allowable speed of 1.8 million $d_m n$
: Over 3 times that of a standard deep groove ball bearing

(2) Superior cage strength (compared to standard cage)
: Tensile strength 1.6 times
: Centrifugal force deformation 1/8
: Heat resistance temperature improved by 30 ˚C

Fig. 2 shows the results of analyzing the amount of cage deformation (outer radial displacement) due to centrifugal force under bearing inner ring rotating conditions. **NTN**’s “High Speed Deep Groove Ball Bearing for EV/HEV” has an optimized resin material and resin cage design that prevents ball interference at high speeds. Note that the developed product can operate at speeds up to 3 times higher than a conventional bearing and still maintain sufficient clearance with the cage pocket. This also prevents increased bearing torque and temperature rise during operation.

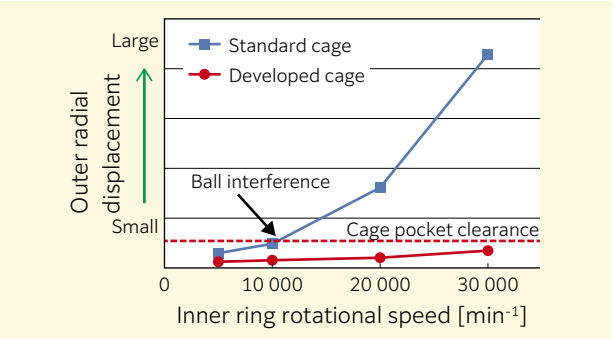

Fig.2 Difference in deformation due to centrifugal force (standard cage vs. developed “high speed” cage)

4. Summary

Increasing the speed of the motor is the most effective way of improving EV motor efficiency. This product responds to demands from customers to increase the speed of bearings, and also contributes towards achieving a decarbonized society. Furthermore, **NTN** has recently achieved a $d_m n$ value of 2.2 million due to the optimization of heat balance.[2] In the future, **NTN** will continue to support the need for increased allowable speeds using our expert knowledge in high speed operating technology.

References

1) Masahiko Satoda, Goro Nakao, Grease Lubricated High-speed Deep Groove Ball Bearing for EV and HEV Motor, NTN TECHNICAL REVIEW, No.83, (2015) 81-85.
2) Single page in Nikkan Kogyo Shimbun dated April 28, 2022.

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[*1] $d_m n$ value refers to an index that represents bearing rotational performance, and is the bearing pitch diameter (mm) × rotational speed (min^{-1}).

Award Winning Products

2020 Japanese Society of Tribologists (JAST) Technology Award

Development of Super Long-Life Tapered Roller Bearings for Automobile

Hiroki FUJIWARA Takashi KAWAI Chikara OHKI

1. Introduction

NTN has developed "Super Long-Life" Tapered Roller Bearings that can be used on automobile transmissions and differentials as well as in electric drive devices (reducers for e-Axle). This product received the 2020 Technology Award from the Japanese Society of Tribologists.

This bearing has an increased resistance to misalignment and contamination and a higher allowable speed. These advancements are possible due to improvements made to the shape of sliding contact areas, the heat treatment method for grain refinement of crystal grain in bearing steel, and the technology used to design the shape of rollers that minimizes the contact stress at the rolling contact surface of roller elements and the raceway surface. These factors enable the automobile drive device to be more compact and lighter in weight, which has been praised for its ability to improve both fuel and power consumption efficiency.

The product that received the award was commercialized as "ULTAGE Tapered Roller Bearing for Automotive Application" **(Fig. 1)**.

Fig. 1 ULTAGE Tapered Roller Bearing for Automotive Application

2. Structure

Fig. 2 shows a schematic drawing of ULTAGE Tapered Roller Bearing for Automotive Application.

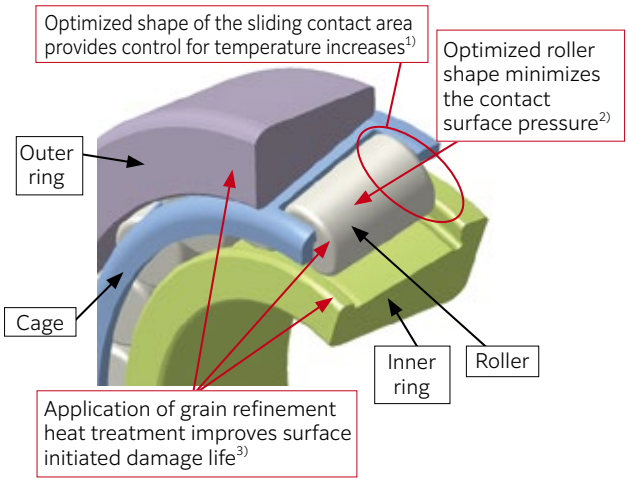

Fig. 2 Structure of ULTAGE Tapered Roller Bearing for Automotive Application

3. Features

(1) The world's highest level in high-load capacity
: Basic dynamic load rating[4)] 1.3 times
(2) Long operating life (comparing basic rating life[4)])
: Standard heat treated type 2.5 times or more
: Grain refinement heat treated type 3.8 times or more
(3) The world's highest level in high rotational speed performance
: Allowable speed[5)] Improvement of approx. 10 %
(4) Allowable misalignment[5)] (misalignment amount)
: Allowable misalignment Up to 4 times

4. Summary

This product was developed to allow for longer operating life for tapered roller bearings. The bearing can also be made smaller dimensionally and achieve the same previous service life. This contributes to making automobile drive devices smaller and lighter, and can also make automobiles more efficient in terms of fuel and power consumption. Furthermore, the longer operating life technology we have developed for this product can also be applied to other areas, which we hope will greatly contribute towards higher optimization of various machines and achieve carbon neutrality.

References

1) Yasuhito Fujikake, Takanori Ishikawa, Susumu Miyairi, ULTAGE Tapered Roller Bearing for Automotive Application, NTN TECHNICAL REVIEW, No. 85, (2017) 51-55.
2) H. Fujiwara et al., Optimized Logarithmic Roller Crowning Design of Cylindrical Roller Bearings and Its Experimental Demonstration, Tribol. Trans., 53 (2010) 909-916.
3) C. Ooki, Improving Rolling Contact Fatigue Life of Bearing Steels Through Grain Refinement, SAE Technical Paper Series, 2004-01-0634.
4) JIS B 1518 (2013)
5) NTN "Ball and Roller Bearings Catalog" (CAT. No. 2203/J)

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Award Winning Products

2021 Japanese Society of Tribologists (JAST) Technology Award

Low Friction Technology of Sealed Ball Bearings for Transmission

Tomohiro SUGAI　Katsuaki SASAKI　Takahiro WAKUDA

1. Introduction

Lower torque and long operating life are needed for automotive transmission bearings to achieve carbon neutrality. The lubricating oil inside a transmission has contaminants such as gear wear debris which can cause the service life of a rolling bearing to decline. Therefore, countermeasures are provided using methods such as ① preventing contaminants from entering the bearing using a contact seal and ② applying special heat treatment to the rolling bearing ring to improve the service life against contaminants. However, ① places restrictions on the allowable speed due to increased running torque due to the seal and heat generated at the seal. Furthermore, ② is not sufficiently effective at suppressing the decline in service life in comparison with the bearing service life in an environment with no contaminants.

To respond to these issues, **NTN** has developed technology to reduce running torque while maintaining sufficient service life even when contaminants are present in the lubricating oil[1,2]. This technology received the "2021 Japanese Society of Tribologists Technology Award", which is given for excellent new technology in the field of tribology. This paper introduces this technology.

2. Overview of award-winning technology

With conventional contact seals, the seal sliding surface contacts the inner ring and because a sufficient oil film does not form at the operational speed range, there is a comparatively high drag resistance torque at the seal. In contrast, this technology provides arc-shaped micro convexities on the contact seal sliding surface as shown in **Fig. 1**. These micro convexities generate a fluid film due to the "wedge film effect" between the seal sliding surface and inner ring under oil lubrication. This results in a fluid lubrication state at the operational speed range which reduces the running torque by 80 % when compared to conventional contact seals, as shown in **Fig. 2**. This can achieve the same low torque performance as a non-contact seal despite it being a contact seal. Furthermore, the convexities are of a micro height so they can prevent contaminants of sizes that would cause the service life to decline from entering the bearing. This enables the bearing to maintain a service life equal to a bearing used in an environment with no contaminants.

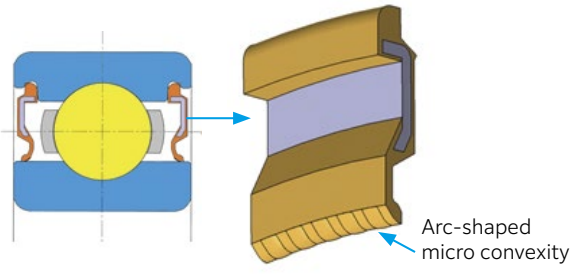

Fig. 1 Schematic drawing of developed seal

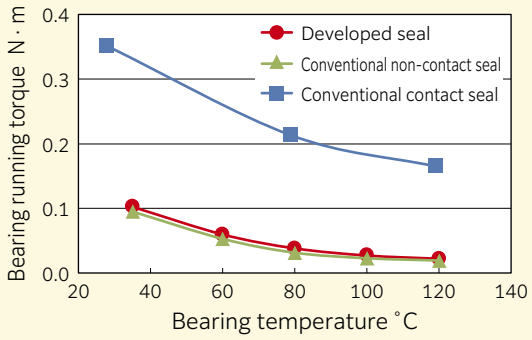

Fig. 2 Bearing running torque experimental results

Additionally, this seal reduces sliding heat generated at the seal contact area so it can also be used under peripheral speed conditions that are two or more times greater than that of a conventional contact seal.

3. Summary

This technology can reduce the running torque of transmission bearings while maintaining sufficient service life even with contaminants in the lubricating oil. This can contribute towards better fuel economy in automobiles. Furthermore, the bearing size can be smaller due to improved reliability which can make automobiles lighter in weight. It can also respond to the demand for speed increases that accompany the electrification of vehicles.

References

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2) Tomohiro Sugai, Katsuaki Sasaki, Takahiro Wakuda, Low Friction Technology of Sealed Ball Bearings for Transmission, Tribology Congress, 2022 Spring Tokyo Proceedings, (2022) B6 85-86.

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Award Winning Products

2021 Japanese Society of Tribologists (JAST) Best Paper Award

Estimation Method of Micropitting Life from *S-N* Curve Established by Residual Stress Measurements and Numerical Contact Analysis

Naoya HASEGAWA Takumi FUJITA Michimasa UCHIDATE Masayoshi ABO Hiroshi KINOSHITA

1. Introduction

The above-mentioned paper[1] submitted to the Japanese Society of Tribologists (non-profit organization) academic journal "Tribology Online" received the 2021 Best Paper Award. The content of this paper is introduced below.

2. Overview

Peeling (referred to as micropitting in the paper) is the typical damage seen on bearings under severe lubrication conditions. It refers to a concentration of micro spalling caused by cyclic contact of projections on rough surface. This paper proposed a new peeling life estimation method utilizing experimental results.

This method estimates the peeling life using the following procedure.

1) A rolling fatigue test is conducted under various operating conditions. Time series data (hereafter, stress history) for cyclic stress at areas of projection contact and peeling life during each test is acquired. The stress history is estimated using the measurement results of surface roughness and residual stress during the operation.
2) Regression analysis is performed on the obtained data, and a *S-N* curve that shows the relationship between cyclic stress and peeling life is created.
3) A preliminary test simulating the subject operating conditions is conducted. Stress history under those conditions is obtained. The peeling life is then estimated using the *S-N* curve created in 2) above and Miner's rule.

To estimate peeling life under various conditions, actual measured data was utilized to increase the precision of life estimation. Furthermore, another feature of this method is that it considers the effect of residual stress on life, something that was difficult to do in the past. However, it must be noted that the application range of this estimation method is limited to pure rolling and boundary lubrication conditions.

Fig. 1[1] shows the relationship between the actual life L_{act} and the peeling life L_{est} estimated using this method. The median, minimum value and maximum value of the life ratio (L_{act} / L_{est}) is 0.89, 0.49 and 1.82 respectively. This precision is comparable to or better than the generally used spalling life estimation of the rolling bearing. This method is considered sufficiently applicable as an estimation method for peeling life.

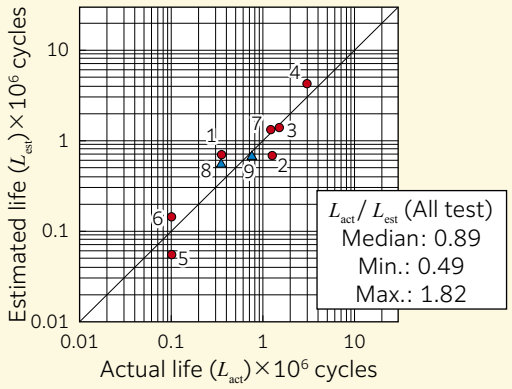

Fig. 1 Relationship between estimated life and actual life[1]

3. Summary

Even greater progress is expected in the future to achieve higher efficiency of machines for achieving carbon neutrality by lowering the viscosity of lubricating oils. This increases the likelihood of bearings being used under thin lubrication conditions. Life estimation under conditions similar to those used in this study will become an important technology for maintaining the reliability of bearing life prediction. In the future, **NTN** will strive to increase the application range of this estimation method and further improve its accuracy.

References

1) N. Hasegawa, T. Fujita, M. Uchidate, M. Abo & H. Kinoshita: Estimation Method of Micropitting Life from *S-N* Curve Established by Residual Stress Measurements and Numerical Contact Analysis, Tribology Online, 14, 3 (2019) 131.

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Award Winning Products

2021 New Energy Awards, New Energy Foundation Chairman Award (products and services category)

DLC Coating Spherical Roller Bearing for Wind Turbine Main Shaft

Kazumasa SEKO Takashi YAMAMOTO Masaki NAKANISHI

1. Introduction

"DLC Coating Spherical Roller Bearing for Wind Turbine Main Shaft" received the "New Energy Foundation Chairman Award (products and services category)" of the 2021 New Energy Awards sponsored by the New Energy Foundation.

The award-winning product substantially improves the wear resistance of the raceway surface and rolling contact surface of rolling elements by applying a DLC (diamond-like carbon) coating* to the rolling contact surface of rolling elements. This has been highly regarded for its significant contribution towards improving the reliability of wind turbines.

* A hard film consisting of a mixture of a diamond structure and graphite structure

2. Structure

Fig. 1 shows the structure of the DLC Coating Spherical Roller Bearing for Wind Turbine Main Shaft.

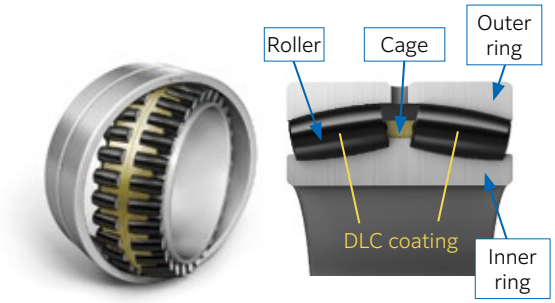

Fig. 1 DLC Coating Spherical Roller Bearing for Wind Turbine Main Shaft

3. Features

When there is insufficient lubrication during operation with conventional spherical roller bearings, metal on the roller raceway surface and rolling contact surface of rolling elements makes contact, resulting in wear on the raceway surface. This contact and resultant wear causes spalling and cracks to occur.

The DLC Coating Spherical Roller Bearing for Wind Turbine Main Shaft can suppress wear on the raceway surface even under harsh lubrication conditions by applying a DLC coating. The DLC coating has a 3-layer structure that provides excellent adhesion to the base material on the rolling contact surface of rolling elements.

During a wear test on smaller sized bearings, **NTN** confirmed that wear depth on the outer ring raceway surface was suppressed by 1/9 or less in comparison with a conventional product **(Fig. 2)**.

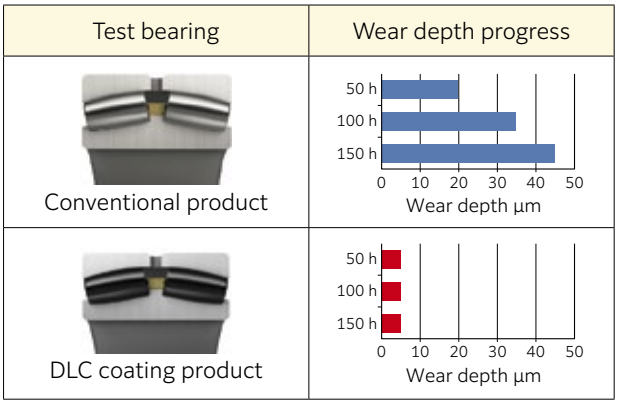

Fig. 2 Wear test results

4. Summary

The main bearings on a wind turbine repeatedly rotate and stop based on wind conditions, and are used under harsh lubrication conditions. Moreover, replacing the main bearings is not an easy task. Therefore, it is necessary to avoid spalling and cracks due to wear on the main bearings because such factors are directly linked to a drop in the reliability of wind turbines.

DLC Coating Spherical Roller Bearing for Wind Turbine Main Shaft is a product that responds to these issues, and can contribute towards improving the reliability of wind turbines by developing the market for this type of product.

References

1) Michio Hori, Yusuke Yamada, New Products and Improved Reliability of Main Bearings for Wind Turbine Generators, NTN TECHNICAL REVIEW, No.88, (2021) 15-20.

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