Low Friction Hub Bearing III

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The Fuel efficiency regulations have been strengthening, therefore the good fuel efficiency is one of the important requirements from the field. Based on this background, **NTN** has been developing the low friction Hub Bearing continuously.

The Low Friction Hub bearing III applicable to such around 60% low torque requirement is introduced in this report.

1. Introduction

Recently, regulations on fuel efficiency and CO_2 emissions have been enhanced globally which has increased the importance of vehicle energy consumption reduction. As a result hub bearings that support wheel rotation are required to further reduce running torque in addition to satisfying basic performance such as operating life and strength.

NTN, which has a high share of hub bearings for vehicles, has long been dedicated to R&D of low consumption technologies for hub bearings. **NTN** has proposed various technologies to achieve the objective[1)-3)].

In this article Low Friction Hub Bearing III is discussed which reduced running torque by 62% when compared to conventional products. It accomplishes this by combining existing items with newly developed grease for reducing torque.

2. Development of Low Torque Hub Bearings

2.1 Structure of Hub Bearings and Contributing Factors for Increasing Torque

An example of the 3rd generation hub bearings is shown in **Fig. 1**.

The torque of hub bearings consists of rolling resistance of the bearing and the sliding resistance of the seals (outer seal and inner seal). Each of them represents approx. 50% of the entire torque. Various reduction technologies have been developed for each of the contributing factors shown in **Fig. 2**. For rolling resistance, optimization of bearing specifications and improvement of bearing internal grease are included. For sliding resistance, improvement of seal rubber material and improvement of seal structure and seal interference are included.

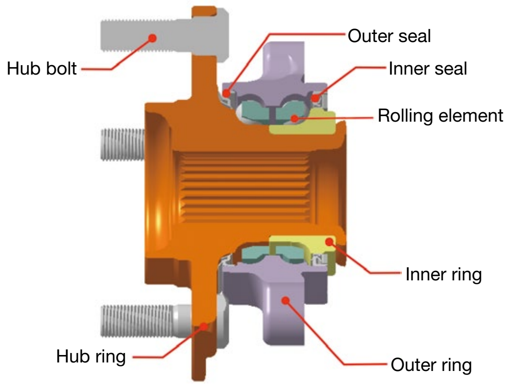

Fig. 1 Example of the 3rd generation hub bearing structure

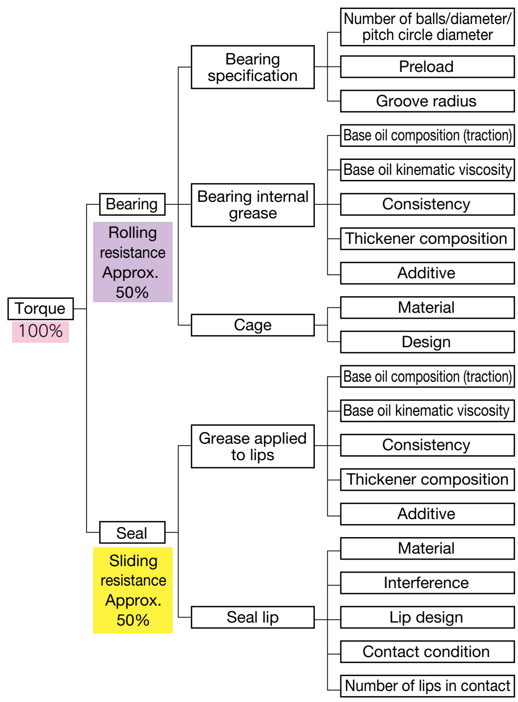

Fig. 2 Contributing factors of bearing torque

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2.2 Transition of Low Friction Hub Bearings

NTN has been developing and proposing design specifications for reducing torque. The hub bearings have evolved into Low Friction Hub Bearing I, II and III by applying these design specifications.

An overview of the evolution is shown in **Table 1** and torque reduction ratios to the conventional products are shown in **Fig. 3**. For Low Friction Hub Bearing I, design optimization was mainly applied and for Low Friction Hub Bearing II, improvement of injected grease and adoption of low friction seals were applied to achieve a significant reduction.

The newly developed Low Friction Hub Bearing III further reduced the torque to achieve a 62% reduction compared to conventional products. This reduction was accomplished by applying the specifications developed in the past and newly developed grease which improved the bearing internal grease used in the Low Friction Hub Bearing II.

Table 1 Transition of Low Friction Hub Bearings

Applied low torque technologies		Low Friction Hub Bearing		
		I	II	III
Bearing	Bearing specification	○	←	◎ * Further improvement
	Bearing internal grease		○	◎ * Further improvement
Seal	Grease applied to lips		○	←
	Lip design	○	←	←
	Lip contact condition		○	←
	Number of lips in contact		○	←

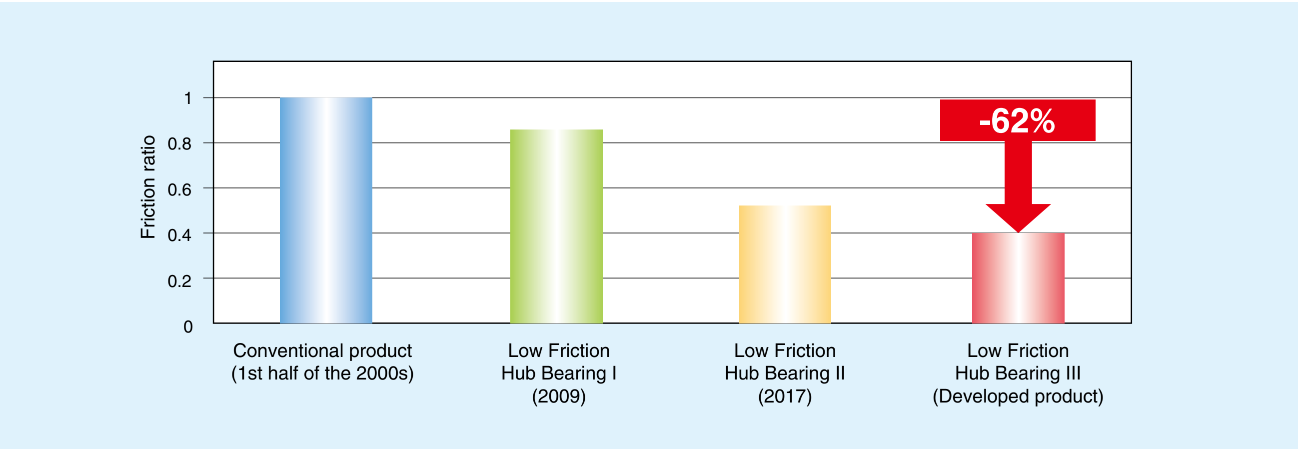

Fig. 3 Transition of development for torque reduction

3. Newly Developed Grease (Reduction of Rolling Resistance)

3.1 Functional Requirements and Specifications of the Developed Grease

The internal grease of hub bearings is required to have the following functions in addition to low friction.

(1) Maintain long operating life by providing sufficient oil film and preventing seizure under the load, temperature and speed conditions of hub bearings
(2) Provide superior fretting resistance under low temperature
(3) Sufficient rust resistance and leakage resistance

Based on the above requirements, the specification of the developed grease was determined as follows: The final concept of the developed grease is shown in **Table 2**.

3.1.1 Reduction of Friction While Maintaining Bearing Operating Life

A microscopic view of the rolling contact point between the ball and groove includes the element of sliding as well. As a result, grease with base oil for reduced kinematic viscosity and low traction coefficient was applied to reduce friction caused by sliding.

When kinematic viscosity of the base oil of the grease is reduced, the risk of insufficient oil film increases. This results in damage to the raceway, as a trade-off condition. Attention is especially required in high load condition as the bearing temperature rises and the grease base oil viscosity further decreases. Low traction base oil was used to control the locally rising temperature for maintaining sufficient oil film thickness and high viscosity index. Vaporization resistance and oxidation resistance were improved to secure long-term lubricity in the high load region, resulting in an operating life equivalent to or better than conventional products.

3.1.2 Fretting Resistance under Low Temperature

In the long-haul transportation of newly manufactured vehicles on railroad freight cars, small vibrations are generated between the raceway and the rolling elements of a hub bearing. As shown by the red arrows in **Fig. 4**, these vibrations squeeze out grease between the raceway and rolling elements creating metal-to-metal contact causing fretting wear. Fretting wear becomes more significant in low temperature conditions where grease tends to be harder and fluidity decreases. If a vehicle in this condition is driven, abnormal noise may be generated.

In order to ensure grease fluidity in low temperature, base oil of low pour point is applied and thickener and additive were optimized resulting in improved low temperature fretting performance.

Table 2 Concept of developed grease

Grease property	Comparison with the conventional product
Base oil	• High viscosity index • Superior vaporization resistance and oxidation resistance • Low pour point • Low traction
Base oil kinematic viscosity	• Low to room temperature: reduce • High temperature: aim for equivalent to conventional product
Thickener	• Improved composition for low friction
Additive	• Selection of additives to compensate the disadvantages brought in by change of base oil

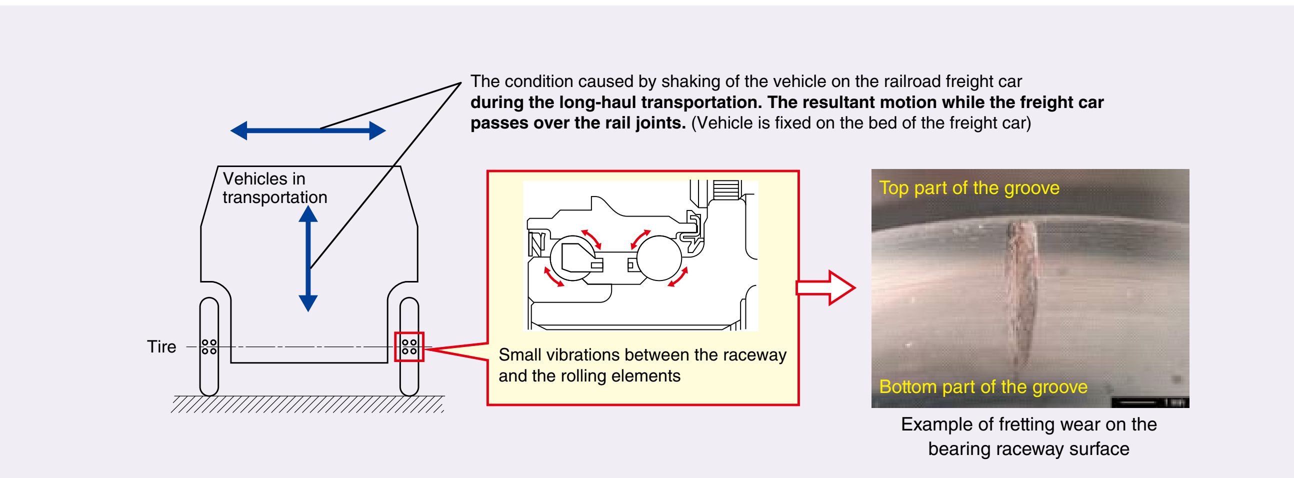

Fig. 4 Mechanism to produce fretting wear

3.2 Evaluation Test

A running torque test was conducted with a hub bearing filled with the developed grease and seals with the rubber lip removed.

The result is shown in **Fig. 5**. The ratio of torque reduction reached to 56% compared to the conventional product (initial 3rd generation hub bearing), validating the reduction effect of rolling resistance of the improved bearing internal grease.

A reliability evaluation test was also conducted to verify the required functionality, as shown in **Table 3**. The bearing with the developed grease satisfied all the development objectives in the test items, fulfilling all the functions required of the bearing internal grease.

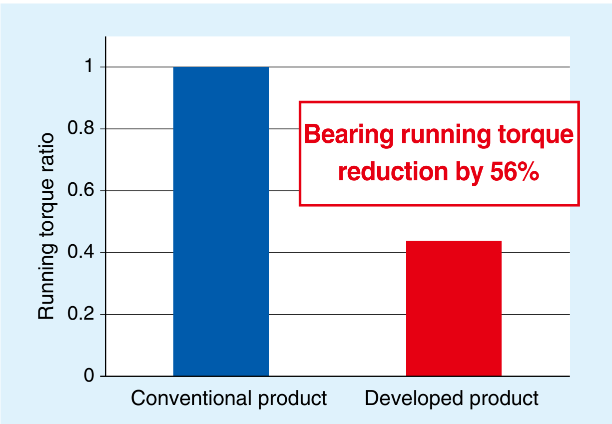

Fig. 5 Running torque test (room temperature)

Table 3 Bearing internal grease reliability evaluation test

Test item	Result
Bearing life from vehicle turns*1	More than 3 times over the rated operating life
Seizure during high-speed rotation*2	No trace of seizure on the bearing raceway surface
Low temperature fretting*3	Wear rate Reduction of 80% compared to the conventional grease

*1 Turning load: 0.6 G load condition
*2 Rotating speed condition when the vehicle speed is 200 km/h
*3 Wear test with small vibrations under the environment of -20°C

4. Ultra Low Friction Seal (Reduction of Sliding Resistance)

The structures of the outer seal and the inner seal adopted by the initial 3rd generation hub bearings (conventional seal) and low friction seals are compared in **Fig. 6**.

Generally, three contacting lips are used to ensure necessary protection against muddy water. However, low friction seals use less contacting lips to further reduce friction. Protection against muddy water, which is degraded by reduction of contacting lips, is preserved by introducing a labyrinth structure and elaborating the lip shape.

Reduction of friction is not only due to the structure but also the rubber material with low friction coefficient, optimized design of the lip contact surface and application of grease dedicated to the lips. Altogether, these items contributed to a reduction of 70% of seal torque compared to conventional products as shown in **Fig. 7**.

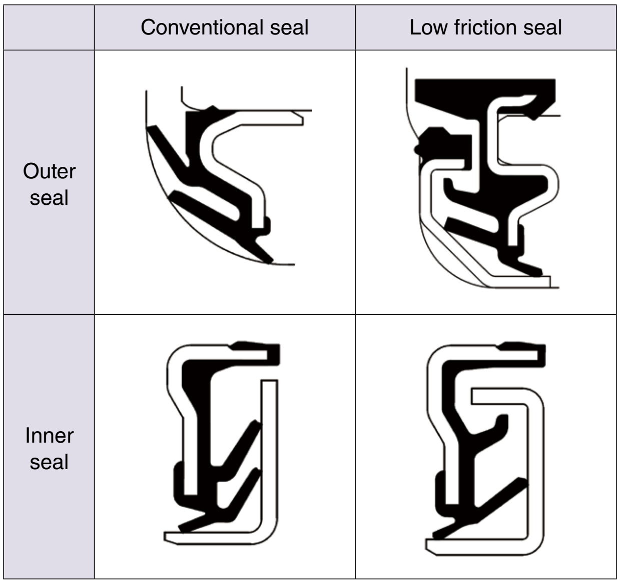

Fig. 6 Structure of conventional seal and low friction seal

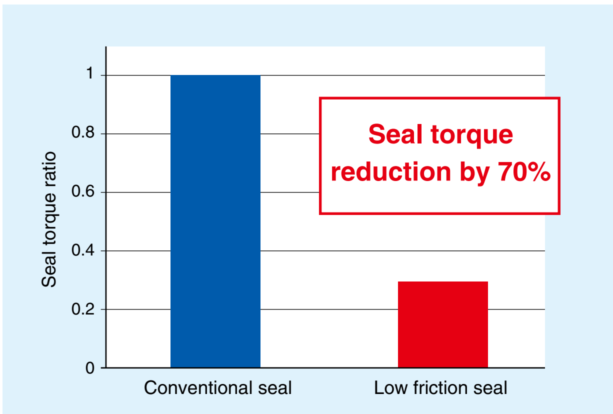

Fig. 7 Seal torque test (room temperature)

5. Low Friction Hub Bearing III

The newly developed bearing internal grease was combined with the existing low friction seal. **Fig. 8** shows the running torque ratio of this bearing. By reducing rolling resistance and sliding resistance of both inner seal and outer seal, 62% of torque reduction effect was obtained for the entire hub bearing.

Fig. 9 shows the performance evaluation chart of the main functional requirements of hub bearings.

It shows that the developed product performed equivalent to or superior to the conventional product in all the functional requirements. The developed product should also be adequate in applications with more severe environments as the fretting resistance in low temperature has significantly improved. In addition, the Low Friction Hub Bearing III decreases the preload upper limit by narrowing the preload range to reduce and stabilize the running torque.

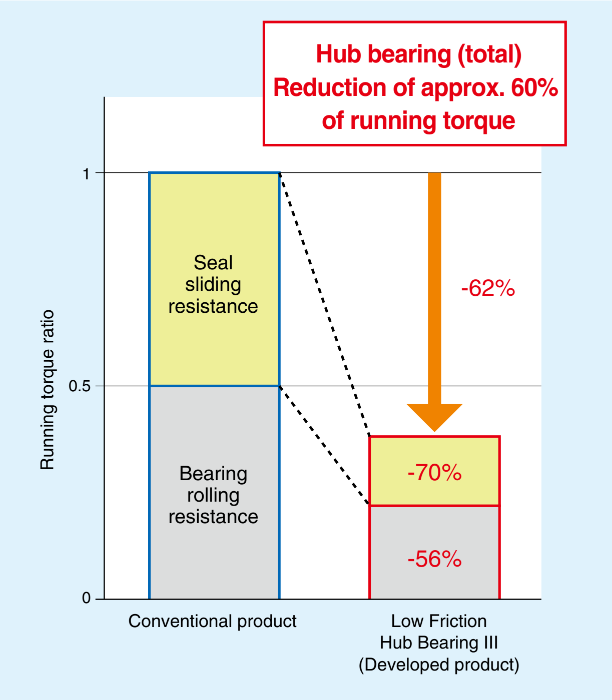

Fig. 8 Example of running torque ratio of hub bearings

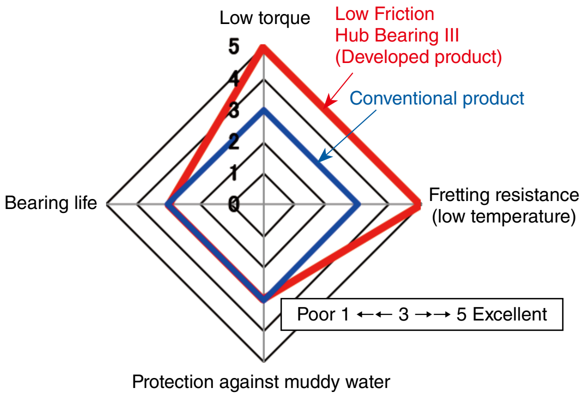

Fig. 9 Performance evaluation chart

6. Conclusion

In response to the demand for low fuel consumption, new bearing internal grease was developed and combined with the existing technology to introduce Low Friction Hub Bearing III to the market. It has reliability equivalent or greater than the existing products while reducing torque. Some of the technology used in the developed product is already adopted by auto manufacturers.

We will continue to strive to contribute to society and develop products to address the global need for further torque reduction and improved reliability.

References

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