

Development of Bearing Seals for Automobile Axles

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Bearings have seals that keep lubricating grease inside, as well as that protect their bearing raceways from dirt and foreign particles. These bearing seals are particularly important functional components for automobile axles that are used in harsh environments. As the global automobile market has been expanding into extremely cold area and inland of continents regions, the environments for axle bearings have been becoming even more severe. With the aim of global standardization, JTEKT has developed a new seal which can withstand harsh environments without increasing sliding torque.

Key Words: axle bearing, water immersion, labyrinth, rust

1. Introduction

In regards to axle bearings used in automobiles, the hub unit has evolved through the 1st, 2nd and 3rd generations, with the production ratio of 3rd generation hub units within JTEKT's overall axle bearing production growing in the 6 years from 2007 to 2012 from 39% to 50%. Globalization of the automobile market means that vehicles must now be fit for not only relatively good driving conditions such as those of Japan, Europe and America, but also the harsh environments which exist in extremely cold areas such as Russia and Northern Europe.

The hub unit seal is an important component which prevents lubricating grease sealed inside the bearing from leaking and prevents the infiltration of foreign particles and dirt. JTEKT has developed a low-torque, highly reliable hub unit seal based on our innovative observation

techniques in order to respond to hub unit use in harsh environments. An overview of this development is given in this report.

2. Assessment of the Current Situation through an Investigation of Hub Units in the Market

The authors collected hub units used in extremely cold areas and in Japan in order to carry out an investigation and assess the current situation. **Figure 1** shows the results of this investigation.

Due to harsh environment exposure, the hub units used in extremely cold areas had rust on the axle seal lip sliding contact portion and the seal lip had also noticeably worn away. Moreover, hub units used in extremely cold areas displayed a tendency for rust on the outer ring end face to be more advanced on the bottom side than the rust on the top side. This tendency is illustrated in **Fig. 1**.

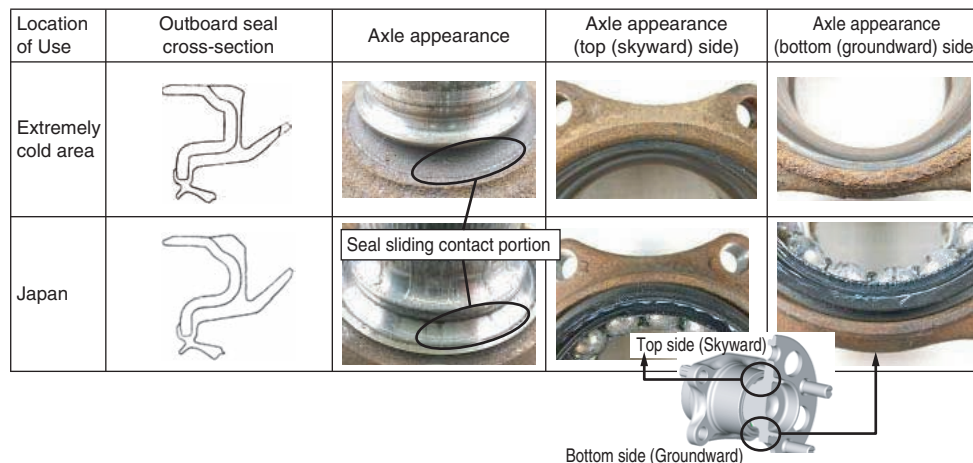


Fig. 1 Comparison results of the hub unit in the market

3. Innovative Observation with Video Footage from Actual Vehicles

By inspecting hub units used in extremely cold areas the authors confirmed that rust progression with these hubs had distinctive characteristics therefore further investigation was done by mimicking the wet environments these axle bearings are often exposed to.

An image recording device was installed on the periphery of a hub unit and footage was taken in a test at JTEKT's Iga Proving Ground (Iga city, Mie prefecture) on a flooded course.



Fig. 2 View of the Iga Proving Ground

When the captured images were analyzed, it became apparent that even though the test vehicle was traveling on a flooded course, virtually no water directly reached the seal periphery on the hub unit outboard side. Muddy water flung up by the tires was contained within the wheel housing and, partly due to the dust cover, only a small amount of water directly made contact with the hub unit mounted in the middle of the wheel. However, it was observed that the muddy water flung up inside the wheel housing traveled to the surrounding parts and reached as far as the hub unit outer ring end face (Fig. 3).

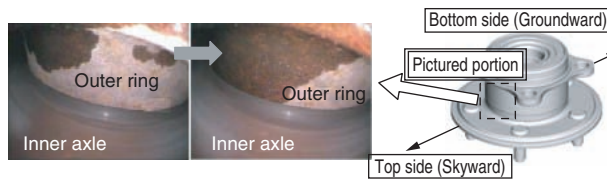


Fig. 3 Hub unit outer ring exposed to water during vehicle drive (Change of water exposure state)

4. A Penetrating Look at Water Flow around an Axle Bearing

In order to examine how rust occurred and its relationship to the muddy water which reached the outer ring end face, the authors investigated the water flow around the outer ring end face of the hub unit.

To get a clear, conclusive view of the labyrinth area, a dummy outer ring and axle were fabricated from transparent plastic and water was poured in from the outer ring upper area in the same way as actual vehicles experience. Figure 4 shows the condition of the outer ring end face as seen from the axle.

The below points were discovered as a result of this investigative technique.

- a) Water penetrates the labyrinth between the axle and outer ring and remains there (Fig. 5-a).



Fig. 5-a Image of water influx onto the end face of the outer ring

- b) The water collected in the labyrinth area forms a water film due to surface tension caused by rotation and the amount of water that is retained is the result of the balance between surface tension and centrifugal force. So even if a greater amount of water is poured in, the amount retained in the labyrinth will not increase.

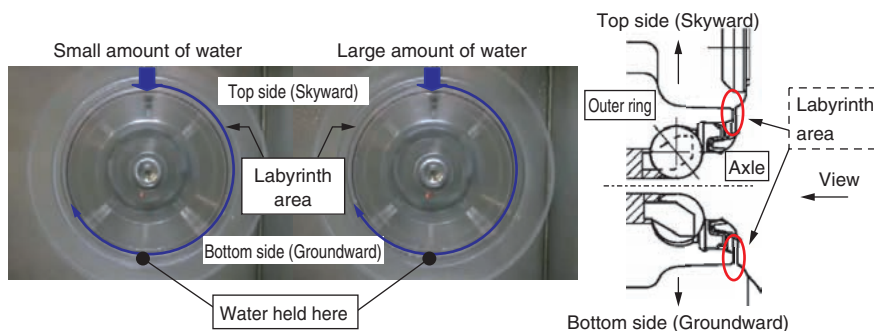


Fig. 4 Checking water flow around the labyrinth on the test stand

Moreover, the water film formed in the labyrinth area due to surface tension during rotation prevents water penetration beyond the labyrinth diameter (Fig. 5-b).



Fig. 5-b Image of water retention on the end face of the outer ring during axle rotation

c) If a rotating hub unit is stopped, the water that had collected inside the labyrinth section due to surface tension will travel to the lower part of the labyrinth and flow out of the hub unit, however some part of this water will remain (Fig. 5-c).

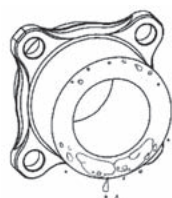


Fig. 5-c Image of water retention on the end face of the outer ring after axle rotation has stopped

It should be noted that the position where the water mentioned in c) above remains is consistent with where the rust on hub units used in extremely cold areas was the most advanced. If the snow-melting agents used in extremely cold areas are added, it is believed that the mechanism causing rust and wear on the seal lip will be as shown in Fig. 6.

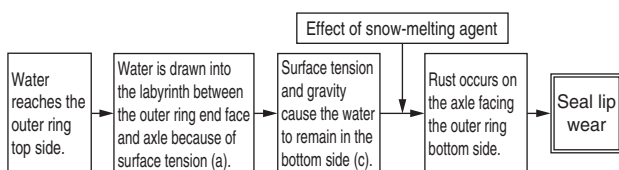


Fig. 6 Mechanism causing rusting and wear on the seal lip

5. Establishment of a Countermeasure and Confirming Effectiveness

By looking at the mechanism causing rust, it is believed that the labyrinth formed from the outer ring and axle retains water and this position is close to the tip of the lip, therefore causing the seal lip to wear. As such, in addition to the conventional duties of the seal, the authors have developed a deflector-equipped seal appropriate for use in extremely cold areas that revises the structure of the

labyrinth itself. The focal points of the development were, (1) making the surface facing the axle small to reduce the amount of water retained, and (2) isolating the position of retained water and the tip of the lip (Fig. 7).

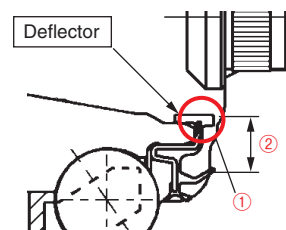


Fig. 7 Seal equipped with deflector

In order to verify the mechanism creating rust and the effectiveness of the deflector-equipped seal, salt was added to the muddy water conventionally used in muddy water endurance tests and a comparative evaluation was made (Fig. 8). First, the conventional product was evaluated and the authors were successful in reproducing the amount of rust on the axle and wear on the seal lip as seen on hub units used in extremely cold areas. When the deflector-equipped seal was evaluated under the same conditions, the life was confirmed to have improved by more than four times that of the conventional, proving its effectiveness (Fig. 9).



Fig. 8 Muddy saltwater test



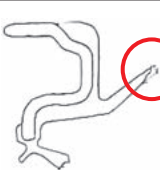
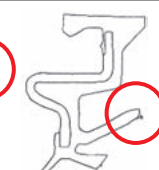
	Conventional part	Post-countermeasure part	Effectiveness of countermeasure
No. of cycles without water intrusion (1 cycle = 12 hr)	15 cycles	Stopped at 25 cycles	No water infiltration
Axle seal sliding contact face			No rust on seal sliding contact face
Condition of seal lip wear			No severe wear on axial lip

Fig. 9 Status after muddy saltwater test

6. Deployment of the Deflector-Equipped Seal

The environments in which automotive axle bearings are used can be broadly divided into 3 applications; the front disk brake, rear disk brake and drum brake. Conventional axle bearings are not designed specifically for these individual applications. This newly developed deflector-equipped seal is believed to be particularly effective for application in front axles that are exposed to severely wet environments. Therefore plans are being made to deploy this seal as the standard specification for front hub unit outboard side seals.

It is also possible to respond to low-torque needs by utilizing this deflector-equipped seal. The configuration of the rear drum brake formed by the brake drum and the dust cover provides good sealing function (Fig. 10), and therefore a drier environment for the axle bearing than the one provided by the front disk brake. Taking the performance of the deflector-equipped seal and given the drum brake configuration which provides a drier environment, in contrast to the 2-lip seal (radial lip and axial lip) type used conventionally, a 1-lip deflector-equipped seal that eliminates the radial lip has been developed (Fig. 11). By adopting this 1-lip deflector-equipped seal, seal sliding resistance can be reduced by 45% at the same time as achieving equivalent or higher muddy water resistance performance when compared to the conventional product. There are also feasibility studies being carried out regarding the 1-lip deflector-equipped seal for the front axle through observational analyses on actual vehicles.

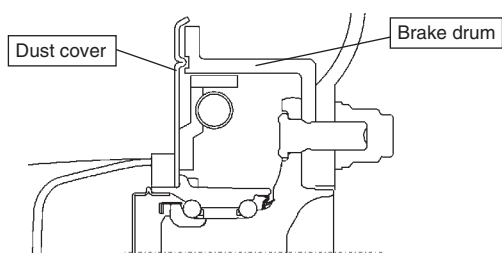


Fig. 10 Example of rear axle labyrinth construction

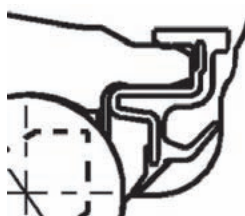


Fig. 11 1-lip seal equipped with deflector

7. Conclusion

A deflector-equipped seal was developed through the application of innovative observation techniques on actual vehicles for use as a globally standard seal suitable for extremely cold areas. Through the development of this deflector-equipped seal, it was also recognized that the hub unit seal could be revised by considering together the configuration of the surrounding parts, including the brake. Conventionally, the standard specification for hub unit seals was the 2-lip type comprising of a radial lip and axial lip, etc., as the design assumed muddy water would constantly penetrate up to the lip area. However, through the innovative observational and experimental techniques used, it was discovered that by revising the configuration of the surrounding parts and the labyrinth in the lip area, the amount of water that reached the seal lip area could be controlled and therefore the number of lips could be reduced. The need for low torque is growing year to year. JTEKT wishes to continue responding to the changing needs of the time with more developments like the new 1-lip seals.

References

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