

Development of Compact Bearing JUCB and Resistant Electric Pitting Bearing JUEB

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In the automotive industry, there is great demand for technologies to respond to the once-in-a-century revolution toward the creation of a carbon-neutral, recycling-oriented, safe, and comfortable society. JTEKT is working to develop such technologies, with a focus on providing next-level improvements in power consumption, mountability, low NV, and added value, as well as reliability and cost reduction. In order to meet these needs, we have developed lightweight and compact products and have developed a lineup of products called the JTEKT Ultra series. In this article, we will introduce JUCB and JUEB.

Key Words: automotive bearing, bearing technology, carbon neutral, compactivity, electric pitting

1. Introduction

In the automobile industry, companies are engaged in technical development to adapt to great changes that occur only once a century, aiming to achieve carbon neutrality, a recycling-oriented society, and a safe and comfortable society. With the electrification of automobile power trains, the requirements of the driveline system and units which use a vehicle traction motor as the drive source are undergoing large changes. For example, eAxles are becoming increasingly compact in order to secure battery mounting space and cabin interior space. In order to meet these changing requirements, it is important to further raise the level of driveline system and unit

performance, and to pursue added value such as smaller sizes and lighter weights.

As shown in **Fig. 1**, JTEKT is developing technologies for a variety of the unit and element components of a next generation electric driveline system (e-Drive system), and aims to be the “No. 1 & Only One” in each field. Among them, we developed the JTEKT Ultra series of products that contribute to smaller unit sizes and lighter weights.

The JTEKT Ultra series contains four products as shown in **Table 1**: the JTEKT Ultra Compact Bearing (JUCB), JTEKT Ultra Earth Bearing (JUEB) for an electric pitting countermeasure, JTEKT Ultra Compact Diff. (JUCD) for eAxles, and JTEKT Ultra Compact Seal (JUCS) differential side seal. Of these, this report explains

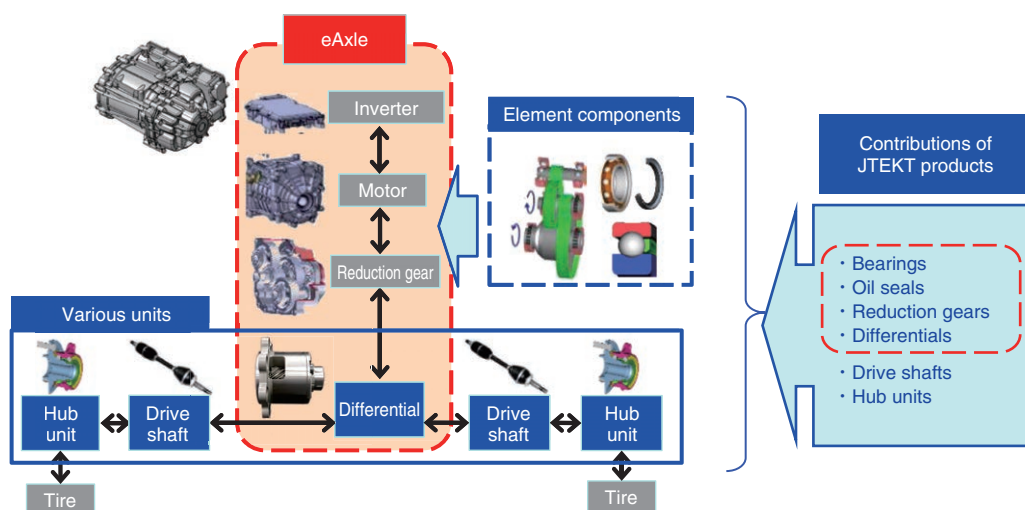


Fig. 1 JTEKT contributions to e-drive systems¹⁾

a summary of the development of the JUCB and JUEB.

Table 1 JTEKT Ultra series

Name	JUCB	JUEB	JUCD	JUCS
Feature	Ultra narrow-width bearing	Conductive bearing	Compact differential	Compact differential side seal
Product				

2. JTEKT Ultra Series

Examples of the use of JTEKT Ultra series in a 150 kW class co-axial type eAxle (hereafter, “co-axial eAxle”) are shown in **Fig. 2**. Compared to a 3-shaft type eAxle where first the input shaft (motor shaft), second the counter shaft, and third the output shaft (differential gear) are arranged in parallel, a co-axial eAxle features higher output density (output per unit volume of the unit). The cross-section at the top of **Fig. 2** shows the structure of a conventional co-axial eAxle composed of an ordinary bearing, oil seal, and open differential. The cross-section at the bottom shows a co-axial eAxle containing a JUCS, JUCB, and JUCD. The width (axial length) is 70 mm shorter than the conventional structure. The mass has also been reduced by 7 kg. In this way, the JTEKT Ultra series can contribute to improving the power efficiency of electric vehicles through more compact and lightweight eAxles.

In addition, damage to the motor shaft bearing known as electric pitting has been a problem, and electric pitting countermeasures are an issue for eAxles.

Details of the JUCB and JUEB bearings that address these issues are described below.

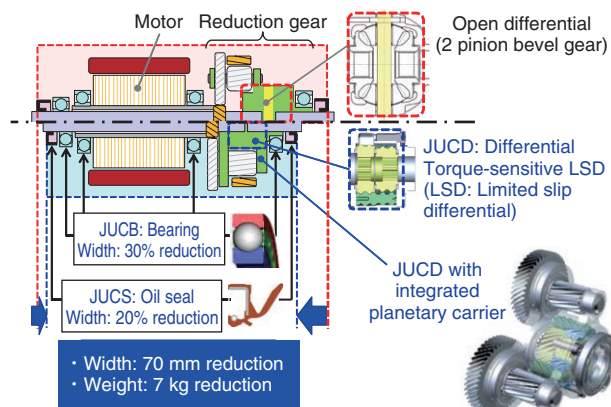


Fig. 2 Co-Axial eAxle improvement using JTEKT Ultra Compact products¹⁾

3. Development of the JUCB (JTEKT Ultra Compact Bearing)

3.1 Features of the JUCB

In order to achieve higher eAxle efficiency in addition to more compact sizes and lighter weights, the motor rotates at high speed. As a result, the bearing used must be smaller in size and also have high-speed rotation performance. With a deep groove ball bearing, ordinarily a resin snap cage is used. However, ensuring performance in high-speed rotation ranges is difficult for the following reasons. When the motor rotation speed rises to 20 000 min⁻¹ or 30 000 min⁻¹, the centrifugal force acting on the bearing increases, and the resin snap cage deforms in the direction that opens the front edge of the pocket opening side toward the outside as shown in **Fig. 3**²⁾. As a result, it interferes with the outer ring, or causes ball jamming (a phenomenon which presses the balls against the inner side of the cage pocket). Increasing the cage ring strength to reduce deformation of the cage caused by centrifugal force increases the cage rigidity; however, it also increases the cage width and bearing width.

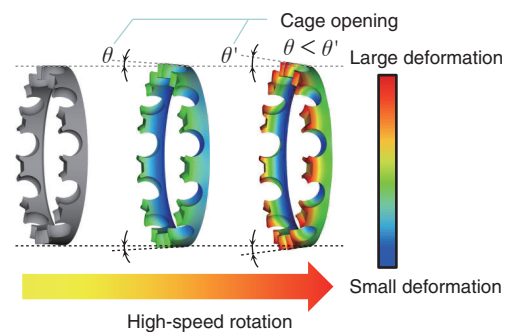


Fig. 3 Deformation of snap cage due to centrifugal force (by CAE analysis)

Therefore, JTEKT developed the JUCB, which achieves both high-speed rotation and compact size (**Fig. 4**). The JUCB uses a cage that combines two resin parts of the same shape, ensuring rigidity of the ring on both sides of the cage. This is able to greatly reduce deformation of the cage caused by centrifugal force (**Fig. 5**). In addition, by reducing the cage width to the limit, the JUCB can reduce the bearing width to a size equal to the ball diameter³⁾.



Fig. 4 JUCB

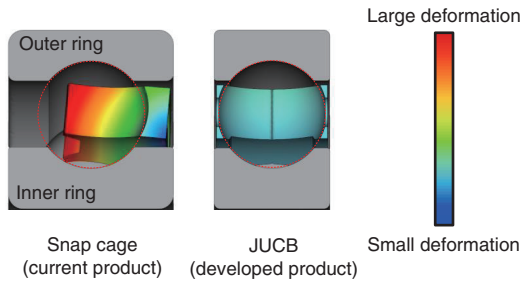


Fig. 5 Analysis of deformation due to centrifugal force

3. 2 JUCB High-speed Performance

In order to check the high-speed performance of the JUCB, a test was conducted which increased the rotation speed in stages. At this test, the temperature of the bearing outer ring was measured, and temperature stabilization and acceleration were performed repeatedly to check for abnormal temperature rise (sudden rise in bearing temperature). The test conditions are shown in **Table 2**, and the test results are shown in **Fig. 6** and **Fig. 7**. With the current resin snap cage, abnormal temperature rise occurred when the speed exceeded 26 000 min⁻¹ ($d_m n$ value*1: 1.4 million). However, with the developed cage, no abnormal temperature rise occurred even at 37 000 min⁻¹ ($d_m n$ value: 2 million). When the cages were observed after the test, marks showing strong contact with the balls were seen on the inside of the pocket with the resin snap cage; however, no abnormal interference with other parts was found with the developed cage. The two-piece cage is thought to increase rigidity and greatly improve high-speed performance.

*1 $d_m n$ value = Rolling element pitch circle diameter (mm) × Inner ring rotation speed (min⁻¹)

Table 2 Temperature rise test conditions

Part number	6207
Bore diameter × Outside diameter × Width	φ35 × φ72 × 17 mm (JUCB: Width 12 mm)
Cage	(1) Snap cage (current) (2) Developed cage (JUCB)
Load	Fr=0.6 kN, Fa=0.2 kN
Rotation speed	Increased in stages (Max. 37 000 min ⁻¹)
Lubricant	Special EV oil
Lubricant supply	100 cc/min

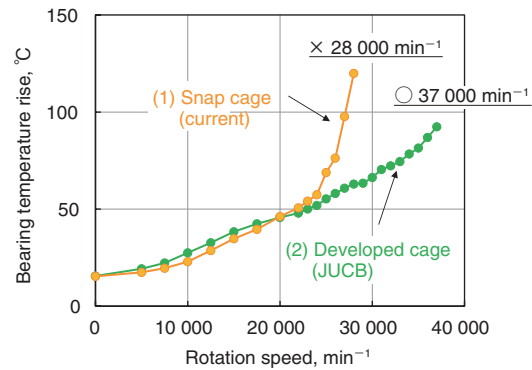


Fig. 6 Temperature rise test result

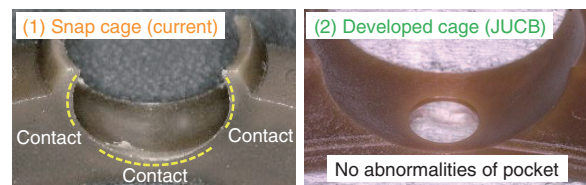


Fig. 7 Close-up photo of cage pocket after test

4. Development of the JUEB (JTEKT Ultra Earth Bearing)

4. 1 Features of the JUEB

With an eAxle, an inverter is used to convert DC current from the battery to the AC current required for motor drive. Electricity flows inside the bearing of the motor that is driven by the inverter, and damage known as electric pitting is an issue. An example of electric pitting marks is shown in **Fig. 8**, and the mechanism of electric pitting is shown in **Fig. 9**.

When electric pitting of the bearing occurs, it causes problems such as noise when rotating and reduced lifetime, affecting the eAxle performance. Countermeasures to electric pitting include the use of ceramic balls which are insulators, and an insulating coating on the surface of the outer ring. However, ceramic balls face the issue of extremely high cost. In the market, electric pitting countermeasures have been commercialized for parts other than the bearing. One example is conductive materials such as a conductive brush or grounding ring; however, these face the issues of mounting space and an increase in assembly processes.

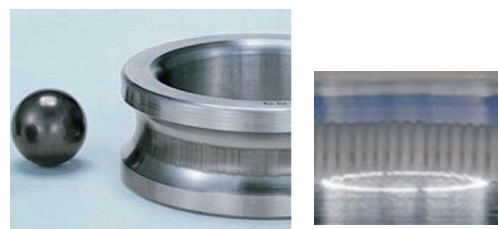


Fig. 8 Electric pitting mark⁴⁾

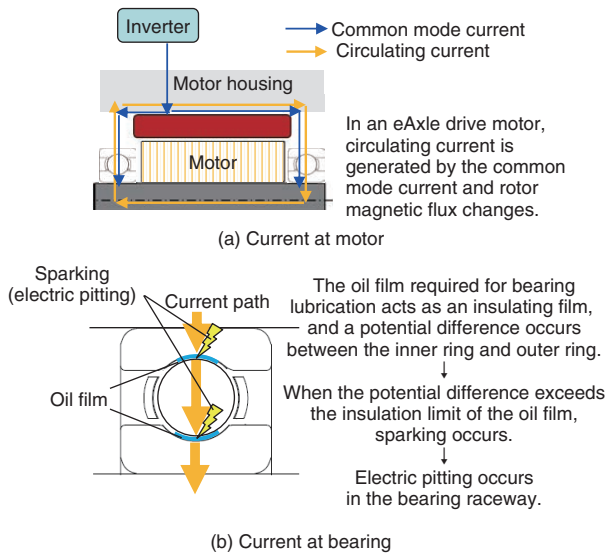


Fig. 9 Mechanism of electric pitting

The cross-section structure of the developed JUEB is shown in Fig. 10. In order to achieve the same or better conductive performance as a conductive brush with the same mounting space as a conventional bearing seal, carbon fiber inserts were formed in conductive rubber, creating a path for the electric current. The seal lip uses a straight shape that allows the carbon fibers to line up easily. As shown in Fig. 11, the use of the JUEB can reduce mounting space compared to a conventional conductive brush. The reduced axial length and lighter weight of the JUEB enable a more compact eAxle, ensure battery mounting space, increase the degree of freedom for tire mounting positions, and otherwise improve the mountability of battery electric vehicle (BEV) parts. As a result, this contributes to improved BEV power efficiency and extended electric range.

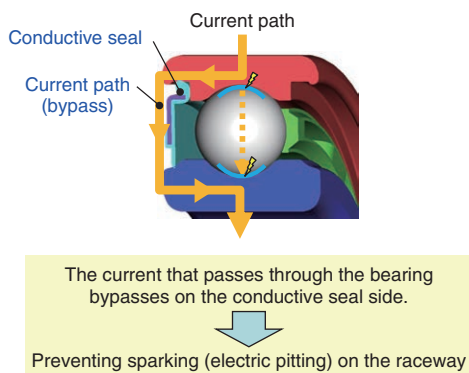


Fig. 10 JUEB concept

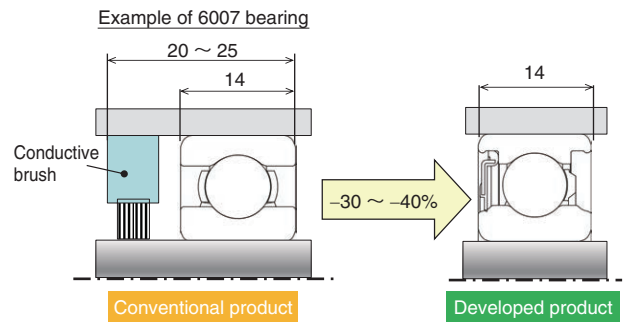


Fig. 11 Example of compactness when using JUEB

4. 2 JUEB Conductive Performance and Electric Pitting Resistance

In order to check the conductive performance of the JUEB, comparative measurements were performed with the impedance of a commercially available conductive brush. The measurement conditions are shown in Table 3, and the relationship between rotation speed and impedance is shown in Fig. 12. The test confirmed that JUEB impedance is equal to that of a conventional conductive brush.

Table 3 Conductivity measurement conditions

Part number	6007
Bore diameter × Outside diameter × Width	$\phi 35 \times \phi 62 \times 14$ mm
Measurement voltage	1.9 V
Measurement frequency	1 kHz

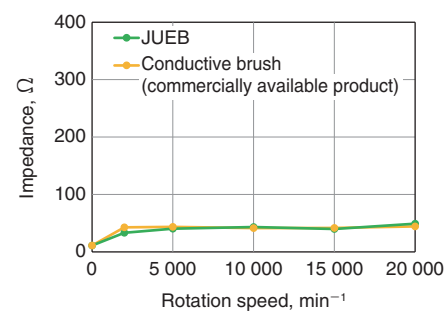


Fig. 12 Conductivity measurement results

Next at a bearing unit rotation test, a comparison test of electric pitting resistance using a commercially available conductive brush and the JUEB was performed under conditions that produce electric pitting. Electric pitting was considered to have occurred when the bearing vibration reached five times the value at the start of the test, and the time until electric pitting occurred was compared. The electric pitting test conditions are shown in Table 4, and the test results are shown in Fig. 13. The electric pitting resistance of the JUEB produced a longer

lifetime than the commercially available conductive brush. Based on the above results, it was confirmed that the JUEB can provide an electric pitting countermeasure without increasing the mounting space.

Table 4 Electric pitting test conditions

Part number	6007
Bore diameter × Outside diameter × Width	$\phi 35 \times \phi 62 \times 14$ mm
Load	Fr = 1.6 kN
Rotation speed	24 000 min ⁻¹
Applied current	500 mA

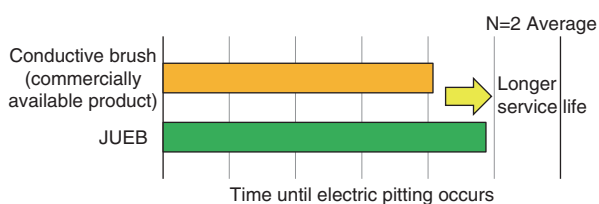


Fig. 13 Electric pitting test results

5. Conclusion

As JTEKT Ultra series products focused on compact size and light weight, we developed the JUCB which reduces the cage width to the limit, and the JUEB which can provide an electric pitting countermeasure in the standard mounting space. The JUCB did not show abnormal temperature rise even at a $d_{m,n}$ value of 2 million, confirming that it has better high-speed performance than a conventional resin snap cage. JUEB impedance is 100 Ω or less, showing conductivity equal to that of an electric pitting countermeasure product in the market, confirming that the JUEB has better electric pitting resistance and a longer lifetime. By using the JUCB and JUEB in combination with the JUCD and JUCS, we intend to contribute to reducing the size and weight and improving the reliability of eAxles.

The electrification trend is not limited to automobiles, and is expanding to construction equipment, agricultural equipment, drones, and other industrial equipment. In the future, the JUCB and JUEB will contribute to meeting requirements for smaller sizes and electric pitting resistance of electric drive unit bearings in all kinds of industries in Japan and overseas.

* JUCD, JUCB, JUEB and JUCS are registered trademarks of JTEKT Corporation.

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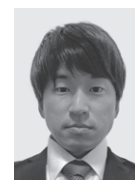
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