NTN TECHNICAL REVIEW No.72（2004）

[New Product]

High Speed and Long Life Double-Row Cylindrical Roller Bearings

Naota YAMAMOTO*
Mamoru MIZUTANI*

NTN has developed a new high-speed and long-life double-row cylindrical roller bearing (NN30xxHSRT6 type) for the **ULTAGE Series** product line. High-speed is accomplished by optimization of the internal design and adoption of a light-weight and high-strength PEEK® resin retainer. Furthermore, the addition of grease reservoirs inside the retainer pockets extends the lubrication life. This paper outlines the development process.

1. Introduction

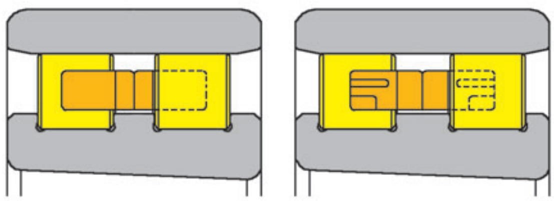
Double-row cylindrical roller bearings are widely used in lathes, machining centers, and other machine tool main spindles that require high rigidity and high accuracy. Nowadays, these machines are increasing their functionality and efficiency. To support the advanced features of modern machinery, the main spindle bearings must run faster and last longer.

Lubrication of the main spindle bearings is primarily air-oil lubrication and grease lubrication. Conventional double-row roller bearings can run up to a $d_m n$ value of 1.2 million under air-oil lubrication and 0.8 million under grease lubrication. Therefore, if higher speed was needed, either angular contact ball bearings or single-row cylindrical roller bearings had to be used.

The ULTAGE Series double-row cylindrical roller bearing offers dramatically faster and longer life performance in both types of lubrication than conventional bearings.

2. Features

The development model focused on optimization of the internal design. The retainer especially, went through a comprehensive review. **Fig. 1** shows the configuration of the development model and the conventional model.



Conventional model **Development model**

Fig.1 Conventional design and new design (HSRT6 Type)

*Industrial Engineering Department Industrial Sales Headquarters

1) Light weight

The retainer material was changed from the conventional high-strength cast brass to PEEK resin (polyether ether ketone). This material change reduced the retainer weight to below 1/4 the conventional retainer weight and also successfully limited heat generation and wear that results from contact between the retainer and the rolling elements during high-speed operation. PEEK is a highly rigid resin and is excellent in heat, wear, and hydrolysis resistance.

2) Super high-speed design for air-oil lubrication

To optimize the retainer profile, a FEM analysis was conducted to determine retainer deformation by centrifugal force in super high-speed operation. (**Fig. 2** shows the analysis example.)

Fig. 3 is the analysis result of the ring thickness. This dimension particularly affects deformation. In the area where the ratio of the ring thickness to the length of the rolling element was below 30%, significant deformation was noticed. To accommodate super high-speed operation, this ratio should be 30% or greater. Furthermore, off-sets were installed at the column ends that could make abnormal contact with the rolling elements, especially during deformation. These off-sets also serve as grease pockets.

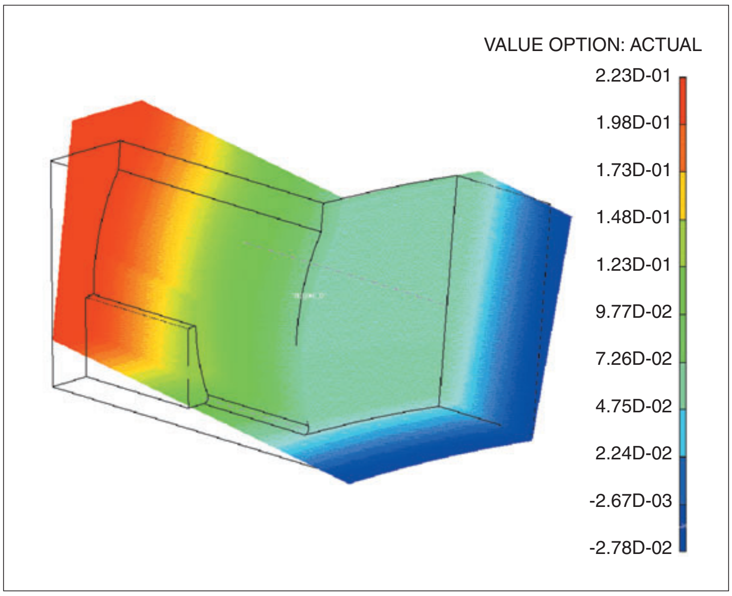


Fig.2 FEM analysis of deformation

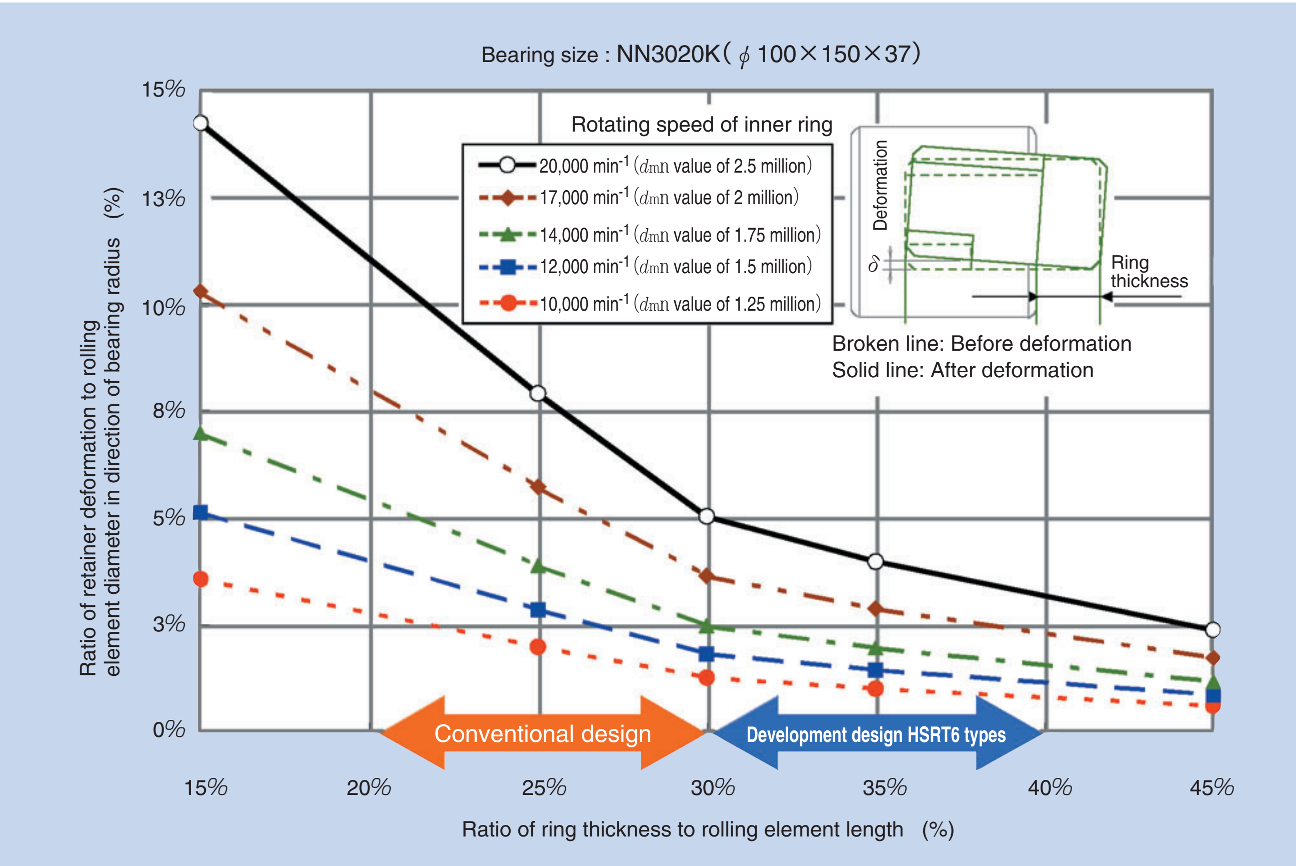


Fig.3 Relation between ring thickness and deformation at super high-speed (FEM analysis of deformation)

3) Long-life design for grease lubrication

Fig. 4 shows the outline of the new retainer structure. As shown, grease pockets are created on the retainer columns to improve grease retention for longer grease life.

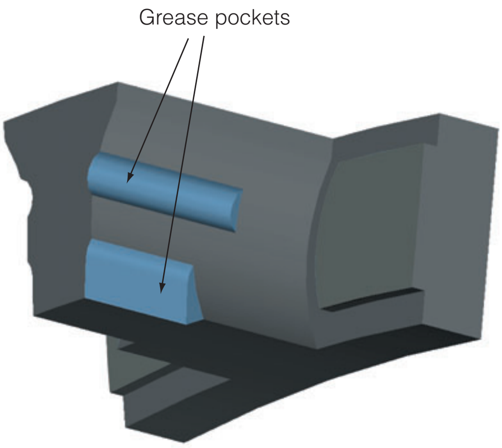


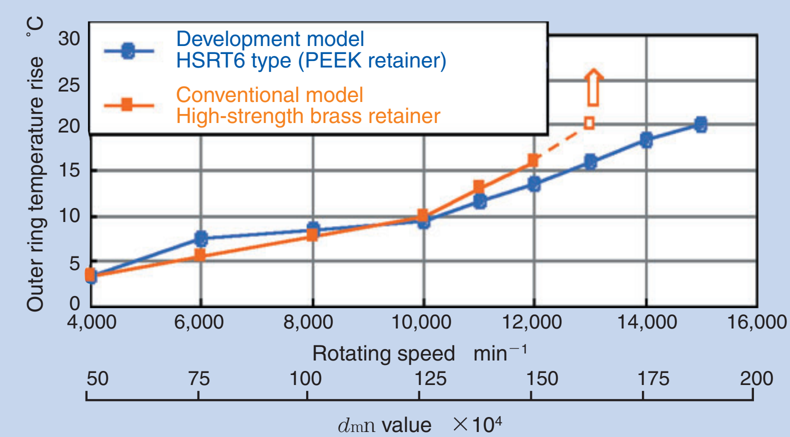
Fig.4 Drawing of the retainer

3. Test results in air-oil lubrication

Fig. 5 shows the test results of this retainer in air-oil lubrication. The conventional retainer (high-strength cast brass retainer) showed a sudden temperature rise at 13000min^{-1}, but the development model (PEEK retainer) was able to withstand high-speed operation up to 15000min^{-1} ($d_m n$ value of 1.9 million).

4. Test results in grease lubrication

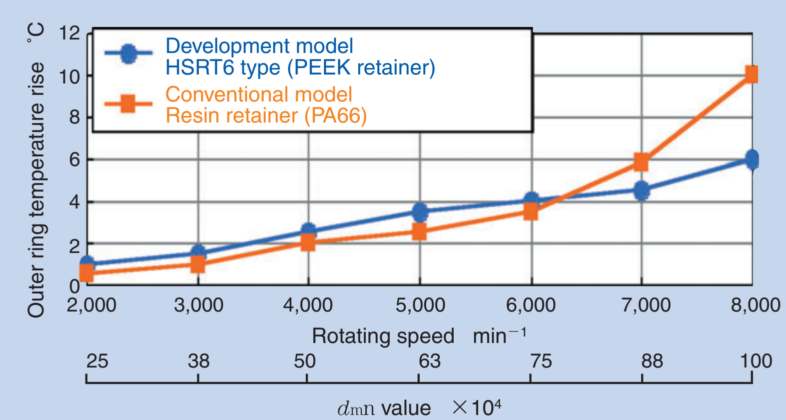
Fig. 6 shows the test results of this retainer in grease lubrication. A comparison of the conventional retainer (PA66 retainer) to the development model (PEEK retainer) showed temperature rise of the outer ring at 7000min^{-1} and a distinctive difference between the two was observed at 8000min^{-1} ($d_m n$ value of 1 million). In the endurance test, the conventional retainer developed high vibration after 1500 hours and the test had to be terminated. Though the bearing didn't sustain any major damage, the rolling elements and the retainer columns had little lubrication.



<Test conditions>
[Development model HSRT6 type (PEEK retainer)]
[Coventional model High-strength brass retainer]

- Bearing size : NN3020K (ϕ100×ϕ150×37)
- Rotating speed : ~15,000min^{-1} ($d_m n$ = 1.9 million)
- Clearance after mounting : 0μm
- Oil supply rate : 0.02mL/20min（VG32）
- Air supply rate : 30NL/min
- Jacket cooling : Provided

Fig.5 Temperature rise test results (air-oil lubrication)



<Test conditions>
[Development model HSRT6 type (PEEK retainer)]
[Conventional model Resin retainer (PA66)]

- Bearing size : NN3020K (ϕ100×ϕ150×37）
- Rotating speed: ~8,000min^{-1} ($d_m n$ = 1 million)
- Clearance after mounting : −5μm
- Grease : MP-1
- Jacket cooling : Provided

Fig.6 Temperature rise test results (grease lubrication)

Consequently, it was determined that the bearing had reached its limit of operation.

On the other hand, the development model retained grease in the retainer's grease pockets after 2000 hours of operation, and was able to continue operation (**Photo 1**).

To confirm the endurance performance of the development bearing, an endurance test is currently on-going at 8000min^{-1} ($d_m n$ value of 1 million) (**Fig. 7**).

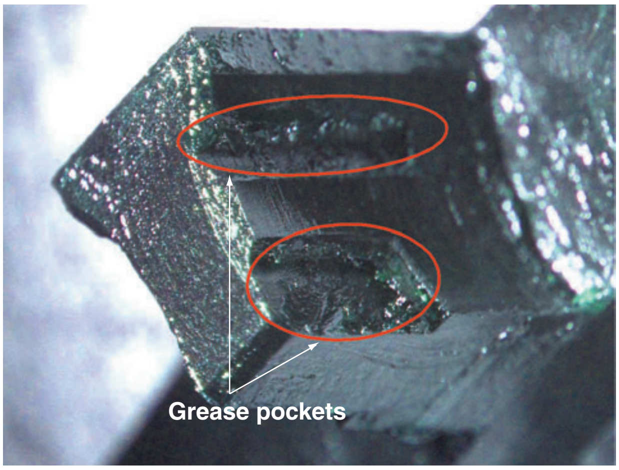


Photo 1 Grease remaining in the reservoirs after 2000(h) running test

5. Bearing composition

The bearing specifications developed in this project should apply to NN3013 ~ NN3026 (Inner Diameter ϕ 65 ~ ϕ 130).

6. Conclusion

The ULTAGE series double-row cylindrical roller bearing, bearing type NN30xx HSRT6, runs at high speeds and lasts longer under air-oil and grease lubrication than conventional double-row cylindrical bearings. This bearing should contribute to increasing functionality and efficiency needs of the lathe main spindles. It will support the development of high-speed and high-rigidity main spindles that will see a growing need in today's market.

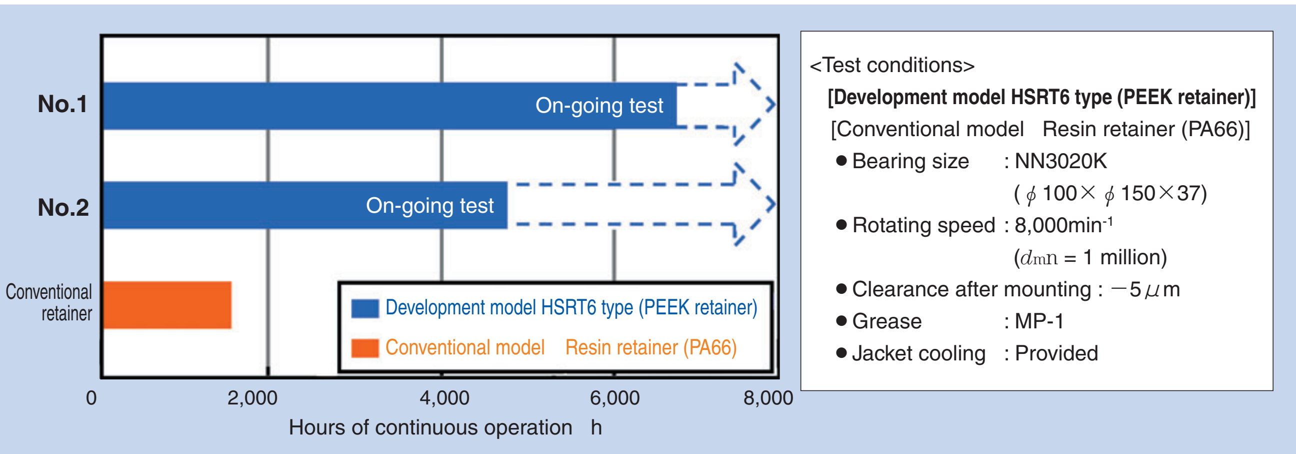


Fig.7 Endurance test results

Photos of authors

Naota YAMAMOTO
Industrial Engineering Dept.
Industrial Sales Headquarters

Mamoru MIZUTANI
Industrial Engineering Dept.
Industrial Sales Headquarters