# HTA U Type ULTAGE Angular Contact Ball Bearings for Axial Loads

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A new angular contact ball bearing has been developed for machine tool applications, particularly lathes, that require a high-speed main spindle with high rigidity and load resistance. This paper introduces the HTA U-type angular contact ball bearing for axial loads, which offers high-speed performance while maintaining the rigidity and load resistance of current bearings.

## 1. Introduction

Angular contact ball bearings for axial loads are used for machine tool main spindles, particularly for lathes, that require high rigidity and load resistance. These bearings are primarily used at low and medium rotating speeds. In recent years, however, there has been a growing need for more efficient and precise machining centers and other machine tools. As machining processes are improved to achieve greater efficiency. High-rigidity main spindles for lathes, etc. Will likely be required to operate at higher speeds. To answer the needs for high-speed operation, **NTN** improved the high-speed performance of the current HTA type angular contact ball bearing for axial loads and developed the HTA U type bearing. This paper describes the features of this product along with the evaluation results.

## 2. Structure of lathe main spindle and bearing

**Fig. 1** shows an example of a lathe main spindle. An angular contact ball bearing for axial loads is used together with a double-row cylindrical roller bearing. The former is to bear axial loads and the latter radial loads. To accomplish this division of load bearing, the bearing OD of the HTA type angular contact ball bearing for axial loads was made smaller than that of the double-row cylindrical roller bearing. This will cause the HTA type angular contact ball bearing for axial loads to receive axial loads only. **Table 1** shows the tolerances for the bearing OD. The HTA type bearings offer two contact angles, 30° and 40°. Bearings of 40° contact angle are typically used when axial rigidity of main spindles is critical. Bearings of 30° contact angle are used when low temperature rise during operation is important.

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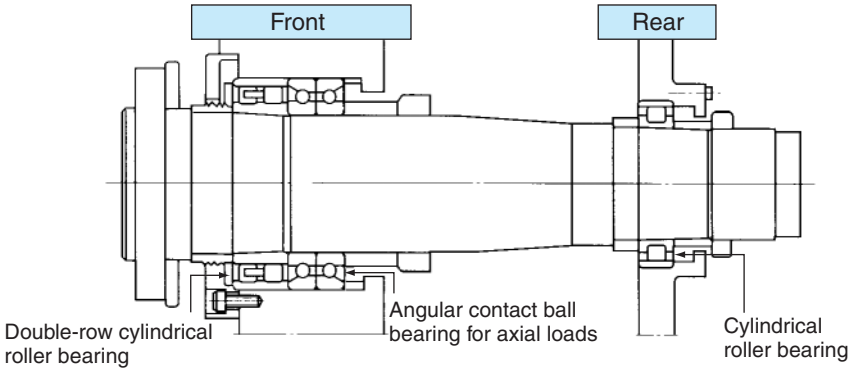


**Fig.1** Structure of main spindle for turning machine

**Table 1** Outside diameter deviation

| Nominal bearing outer diameter mm | | Outer diameter tolerances μm | | | |
|---|---|---|---|---|---|
| | | HTA type P4 L accuracy | | Cylindrical roller bearing P4 accuracy | |
| Over | Incl. | Upper limit | Lower limit | Upper limit | Lower limit |
| 30 | 50 | -25 | -36 | 0 | -6 |
| 50 | 80 | -30 | -43 | 0 | -7 |
| 80 | 120 | -36 | -51 | 0 | -8 |
| 120 | 150 | -43 | -61 | 0 | -9 |
| 150 | 180 | -43 | -61 | 0 | -10 |
| 180 | 250 | -50 | -70 | 0 | -11 |
| 250 | 315 | -56 | -79 | 0 | -13 |
| 315 | 400 | -62 | -87 | 0 | -15 |
| 400 | 500 | -68 | -95 | - | - |

**Photo 1** HTA U type

## 3. Features

### 3.1 Allowable rotating speed

The HTA U type (**Photo 1**) is different from the current bearings in the following areas.

- Internal design (**Fig. 2**) that limits temperature rise at high-speed range
- Inner/outer ring profiles that improve oil discharge in oil lubrication
- Polyamide resin molded cage with its rolling element contact profile that improves lubrication efficiency in grease and air-oil lubrication

The design specifications described above made the bearing run at high-speed and limit temperature rise, thus reaching the allowable dmn value shown in **Table 2**. The operation test results are explained in Section 4.

However, the $d_{\mathrm{m}}n$ value of 1.25 million (30° contact angle, air-oil lubrication) in the table is of the phenol machined cage specifications. The allowable $d_{\mathrm{m}}n$ value for the HTA U type standard polyamide molded cage specifications is up to 1.05 million.

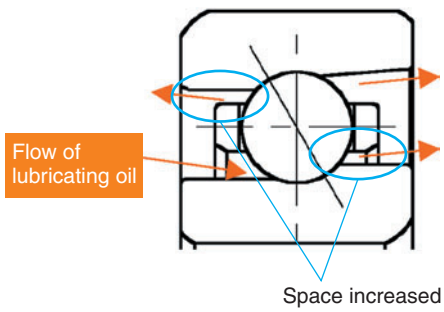


**Fig.2** Flow of lubricating oil

**Table 2** Allowable $d_{\mathrm{m}}n$ value

| | Grease lubrication | Air-oil lubrication |
|---|---|---|
| Contact angle 30° | $100\times10^4$ over the current type 60%UP | $125\times10^4$ over the current type 25%UP |
| Contact angle 40° | $75\times10^4$ over the current type 30%UP | $95\times10^4$ over the current type 10%UP |

### 3.2 Axial rigidity

The internal design of the HTA U type was made to improve high-speed performance at the expense of axial rigidity. However, as shown in **Fig. 3**, the difference in axial deflection between the HTA U and the current HTA types was 1.5 $\mu$m or smaller (at 30° contact angle) when axial load of 5kN was applied, hence the axial rigidity of the HTA U type can be called almost equal to that of the current HTA type.

### 3.3 Load resistance (allowable axial load)

The allowable axial load for bearings is as important a characteristic as axial rigidity. **Fig. 4** compares the current HTA type to the HTA U type in axial rigidity. As you can see, by reviewing the internal design, the allowable axial load for the HTA U type was about 1.3 times that of the current HTA type at the contact angle of 30° and about 1.2 times at 40°.

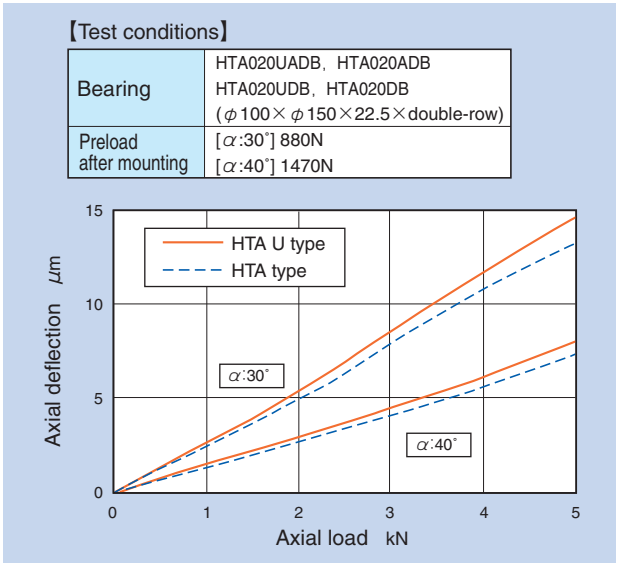


**Fig.3** Displacement in axial direction

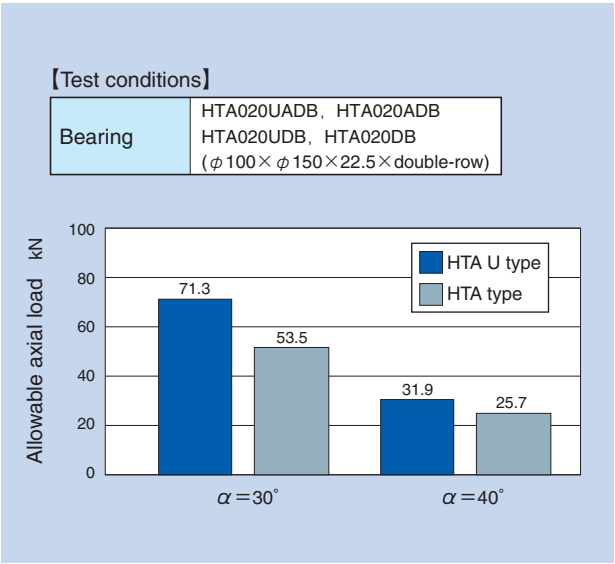


**Fig.4** Allowable axial load

## 4. Operation test results

The structure of the test machine used in the operation test and the test results are shown below.

### 4.1 Structure of test machine

**Fig. 5** shows the structure of the test machine. To simulate actual service conditions, the test bearing is structured not to receive radial loads.

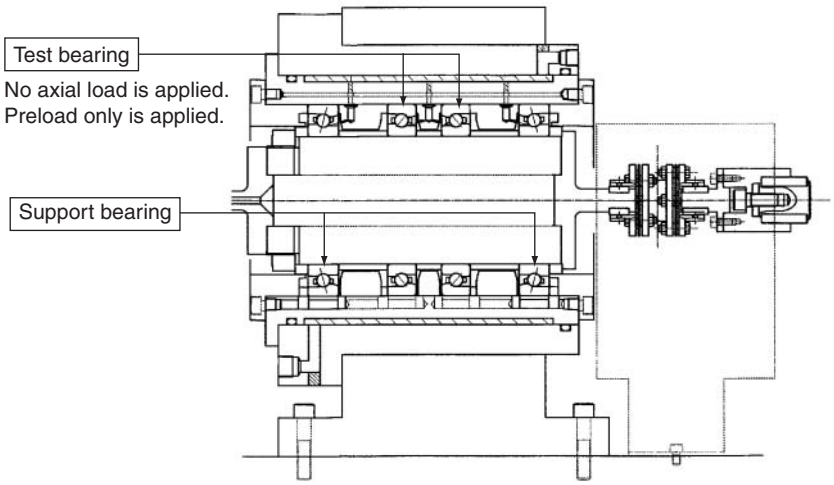


**Fig.5** Test rig for measuring temperature rise

## 4.2 Test results

Figs. 6, 7, 8, and 9 show the operation test results of the bearings with grease lubrication and air-oil lubrication.

All the test bearings showed steady temperature rise up to the allowable dmn values as shown in Table 2.

【Test conditions】

| | |
|---|---|
| Bearing [$\alpha$:30˚] | HTA020UADB<br>HTA020ADB<br>($\phi$100×$\phi$150×22.5×double-row) |
| Rotating speed | ~8000min$^{-1}$ |
| Preload after mounting | 880N |
| Method of lubrication | Grease lubrication |
| Grease used | MP-1 |
| Jacket cooling | Provided, Not provided |

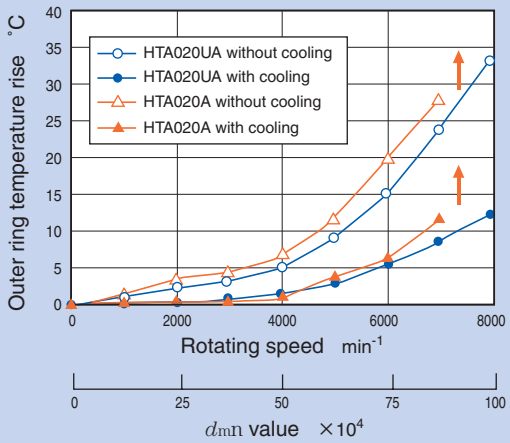


Fig.6 Results of high-speed test (grease lubrication) ( $\alpha$ :30˚)

【Test conditions】

| | |
|---|---|
| Bearing [$\alpha$:30˚] | HTA020UADB<br>HTA020ADB<br>($\phi$100×$\phi$150×22.5×double-row) |
| Rotating speed | ~10000min$^{-1}$ |
| Preload after mounting | 880N |
| Method of lubrication | Air-oil lubrication |
| Oil supply rate | 0.03mL/shot<br>Oil shot interval 5min. |
| Air supply rate | 40NL/min |
| Jacket cooling | Provided, Not provided |

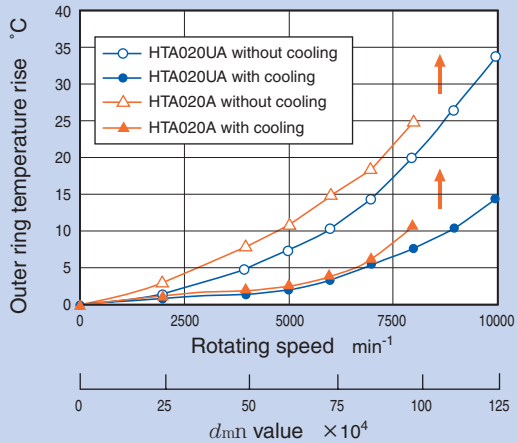


Fig.7 Results of high-speed test (air-oil lubrication) ( $\alpha$ :30˚)

【Test conditions】

| | |
|---|---|
| Bearing [$\alpha$:40˚] | HTA020UDB<br>HTA020DB<br>($\phi$100×$\phi$150×22.5×double-row) |
| Rotating speed | ~6000min$^{-1}$ |
| Preload after mounting | 1470N |
| Method of lubrication | Grease lubrication |
| Grease used | MP-1 |
| Jacket cooling | Provided, Not provided |

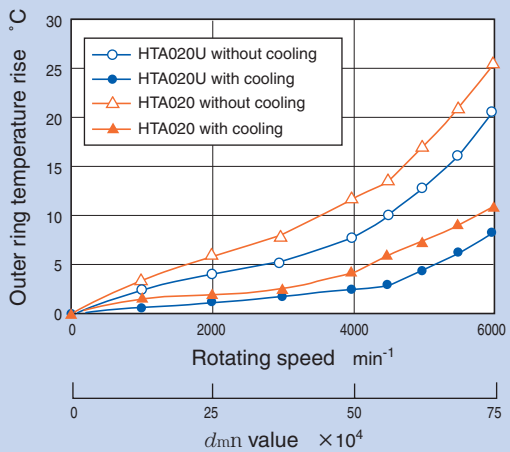


Fig.8 Results of high-speed test (grease lubrication) ( $\alpha$ :40˚)

【Test conditions】

| | |
|---|---|
| Bearing [$\alpha$:40˚] | HTA020UDB<br>HTA020DB<br>($\phi$100×$\phi$150×22.5×double-row) |
| Rotating speed | ~7500min$^{-1}$ |
| Preload after mounting | 1470N |
| Method of lubrication | Air-oil lubrication |
| Oil supply rate | 0.03mL/shot<br>Oil shot interval 5min. |
| Air supply rate | 40NL/min |
| Jacket cooling | Provided, Not provided |

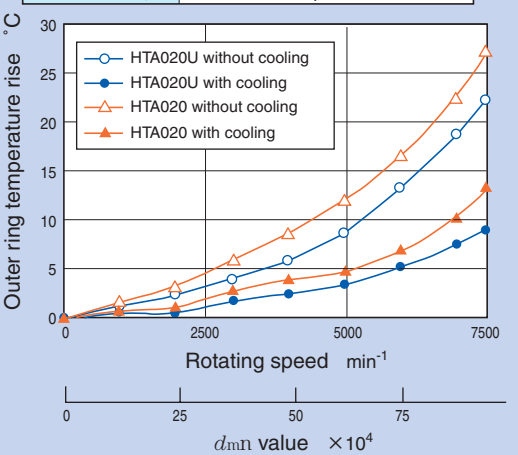


Fig.9 Results of high-speed test (air-oil lubrication) ( $\alpha$ :40˚)

## 5. Standard series

The standard specifications of the HTA U type axial load angular contact ball bearing for machine tool main spindles include, like those of the current HTA type, 30° and 40° contact angles and the 0-series and 9-series diameters. The compatible bearing size for the 0-series is $\phi$50 ~ $\phi$320, and that for the 9-series is $\phi$100 ~ $\phi$320. The rolling elements can be either steel or ceramic balls.

## 6. Conclusion

The HTA U type bearings have achieved high allowable $d_m n$ values, 60% over the current type bearings with grease lubrication and 25% over the same with air-oil lubrication, while maintaining rigidity and load resistance equal to those of the current series. This bearing will meet the needs of high-speed and high-rigidity main spindles that are expected to increase in the near future. **NTN** will continue to develop bearings of longer life and improved handling.

Photos of author

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