TECHNICAL SPECIFICATION

ISO/TS 16799

First edition
1999-12-15

Rolling bearings — Dynamic load ratings and rating life — Discontinuities in the calculating of basic dynamic load ratings

Roulements — Charges dynamiques de base et durée nominale — Discontinuité dans le calcul des charges dynamiques de base

Reference number
ISO/TS 16799:1999(E)

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Attention is drawn to the possibility that some of the elements of this Technical Specification may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 16799 was prepared by Technical Committee ISO/TC 4, *Rolling bearings*, Subcommittee SC 8, *Load ratings and life*.

Introduction

This Technical Specification addresses discontinuities in the calculation of basic dynamic load ratings for radial and thrust angular-contact ball bearings.

The factors used in calculating the basic dynamic load ratings C_r and C_a according to ISO 281 are slightly different for radial and thrust angular-contact ball bearings. The methods for taking into account the influence of thrust loads on bearing life are also different.

Therefore there is a discontinuity in the calculated lives when a bearing with the contact angle α = 45° is first regarded as a radial bearing and then as a thrust bearing. In both cases the bearing is subject to the same external axial load F_a only.

Rolling bearings — Dynamic load ratings and rating life — Discontinuities in the calculating of basic dynamic load ratings

1 Scope

This Technical Specification explains why the load rating factors for calculation of the basic dynamic load ratings C_r and C_a are different for radial and thrust angular-contact ball bearings, and shows how these load ratings can be recalculated in order to bring about correct comparisons under the same conditions.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this Technical Specification. For dated references, subsequent amendments to, or revisions of, this publication do not apply. However, parties to agreements based on this Technical Specification are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 281:1990, *Rolling bearings — Dynamic load ratings and rating life.*

3 Symbols

For the purposes of this Technical Specification the symbols used in ISO 281 as well as the following apply.

C_{ar} which is the adjusted basic dynamic axial load rating for a radial bearing ($\alpha \leqslant 45°$), in newtons;

C_{aa} which is the adjusted basic dynamic axial load rating for a thrust bearing ($\alpha > 45°$), in newtons;

r_i which is the cross-sectional raceway groove radius of inner ring, in millimetres;

r_e which is the cross-sectional raceway groove radius of outer ring, in millimetres;

λ which is the contact stress factor.

4 Different factors for calculating load rating and equivalent load for radial and thrust angular-contact ball bearings

When a life comparison is made between a radial and a thrust bearing, both bearings are assumed to be subject to the same external axial load F_a only.

For angular-contact thrust ball bearings

$$L_{10} = \left(\frac{C_a}{P_a}\right)^3 = \left(\frac{C_a}{F_a}\right)^3$$

Included in the calculation of C_a are

— the osculation between balls and raceways $r_i/D_w \leqslant 0{,}54$ and $r_e/D_w \leqslant 0{,}54$,

— a contact stress factor $\lambda = 0{,}9$,

— the Y factor ($C_a = C_r/Y$)

where

$$Y = \frac{0{,}4 \cot \alpha}{1 - 0{,}333 \sin \alpha} \qquad (1)$$

For angular-contact radial ball bearings

$$L_{10} = \left(\frac{C_r}{P_r}\right)^3 = \left(\frac{C_r}{Y\,F_a}\right)^3 = \left(\frac{C_a}{F_a}\right)^3; \quad C_a = \frac{C_r}{Y}$$

Included in the calculation of C_r are

— the osculation between balls and raceways $r_i/D_w \leqslant 0{,}52$ and $r_e/D_w \leqslant 0{,}53$,

— a contact stress factor $\lambda = 0{,}95$.

The Y factor is calculated according to equation (1) if all balls are loaded, as is mostly the case for thrust bearings. The expression $1 - 0{,}333 \sin\alpha$ in equation (1) takes into consideration the negative influence of the fact that all balls are loaded and is included in the f_c values for angular contact thrust ball bearings in Table 4 of ISO 281:1990.

Radial bearings are mainly radially loaded and many balls are unloaded or lightly loaded. The negative influence of the expression $1 - 0{,}333 \sin\alpha$ was therefore reduced when the Y factors were calculated for angular-contact radial ball bearings in Table 3 of ISO 281:1990.

5 Comparing adjusted basic dynamic axial load ratings, C_{ar} and C_{aa}, for radial and thrust angular-contact ball bearings

5.1 General

For certain applications angular-contact ball bearings with contact angles $\alpha \leqslant 45°$ and $\alpha > 45°$ are manufactured with the same osculation between balls and raceways, and sometimes there is a need to calculate and also to compare their true axial load ratings.

The basic dynamic load ratings C_r and C_a can be calculated with the aid of clauses 5 and 6 of ISO 281:1990 or taken from a bearing catalogue, if they are available there.

However, as described in clause 4, C_r and C_a are calculated with different values of osculation, λ factor and Y factor for radial and thrust bearings. If a correct calculation and comparison is to be made, C_r and C_a shall be re-calculated to adjusted basic dynamic axial load ratings C_{ar} and C_{aa}, based upon the same values of osculation, λ factor and Y factor.

The recalculation can be performed with the aid of equations (2) to (5) for two different osculations – radial bearing osculation and thrust bearing osculation – as defined in 5.1 and 6.1.1 of ISO 281:1990.

The comparisons are made for thrust ratings only, since this is most convenient.

The contact angle α is assumed to be constant, independent of the axial load, which means that the accuracy is reduced for bearings with small contact angles, subjected to heavy loads.

5.2 Angular-contact ball bearings with radial-bearing osculation

($r_i / D_w \leqslant 0{,}52$ and $r_e / D_w \leqslant 0{,}53$)

$$C_{ar} = 2{,}37 \tan\alpha \, (1 - 0{,}333 \sin\alpha) \, C_r \quad (2)$$

$$C_{aa} = 1{,}24 \, C_a \quad (3)$$

$$L_{10} = \left(\frac{C_{ar}}{F_a} \right)^3$$

$$L_{10} = \left(\frac{C_{aa}}{F_a} \right)^3$$

5.3 Angular-contact ball bearings with thrust-bearing osculation

($r_i / D_w \leqslant 0{,}54$ and $r_e / D_w \leqslant 0{,}54$)

$$C_{ar} = 1{,}91 \tan\alpha \, (1 - 0{,}333 \sin\alpha) \, C_r \quad (4)$$

$$C_{aa} = C_a \quad (5)$$

6 Examples

6.1 Bearing with $\alpha = 45°$

Compare the adjusted basic dynamic axial load ratings of an angular contact ball bearing with $\alpha = 45°$, when it is regarded as a radial bearing and as a thrust bearing. For the selected bearing $(D_w \cos\alpha)/D_{pw} = 0{,}16$ the bearing has radial bearing osculation.

C_r is calculated according to 5.1 in ISO 281:1990, i.e. $C_r = K f_c$ where K is a constant which includes all parameters that are the same for this radial and thrust bearing. According to Table 2 of ISO 281:1990, $f_c = 59{,}6$. Equation (2) gives

$$C_{ar} = 2{,}37 \times \tan 45° \times (1 - 0{,}333 \sin 45°) \times K \times 59{,}6 = 108\ K$$

According to equation (3), with $f_c = 85{,}1$ from Table 4 of ISO 281:1990 and $C_a = K f_c \tan\alpha$ from 6.1.1 in ISO 281:1990,

$$C_{aa} = 1{,}24 \times K \times 85{,}1 \times \tan 45° = 106\ K$$

After the recalculation of the basic dynamic load ratings $C_{ar} \approx C_{aa}$, which confirms that the discontinuity no longer remains.

6.2 Basic dynamic axial load ratings of two angular-contact ball bearings with 40° and 60° contact angles

Calculate the basic dynamic axial load ratings of two angular contact ball bearings, one with a contact angle of 40° and the other with a contact angle of 60°. Both bearings have the same thrust bearing osculation. $D_w/D_{pw} = 0{,}091$, ball diameter $D_w = 7{,}5$ mm and the number of balls $Z = 27$.

For the 40° bearing $(D_w \cos 40°)/D_{pw} = 0{,}091 \times \cos 40° = 0{,}07$, and then $f_c = 51{,}1$ according to Table 2 of ISO 281:1990.

$$C_r = 1{,}3\ f_c\ (\cos\alpha)^{0{,}7}\ Z^{2/3}\ D_w^{1{,}8} = 1{,}3 \times 51{,}1 \times (\cos 40°)^{0{,}7} \times 27^{2/3} \times 7{,}5^{1{,}8} = 18\ 651$$

According to equation (4)

$$C_{ar} = 1{,}91 \times \tan 40° \times (1 - 0{,}333 \times \sin 40°) \times 18\ 651 = 23\ 493$$

$$C_{ar} = 23\ 500\ \text{N}$$

For the 60° bearing $(D_w \cos 60°)/D_{pw} = 0{,}091 \cos 60° = 0{,}046$, and then $f_c = 61{,}12$ according to Table 4 of ISO 281:1990

$$C_a = 1{,}3\ f_c\ (\cos\alpha)^{0{,}7}\ (\tan\alpha)\ Z^{2/3}\ D_w^{1{,}8} = 1{,}3 \times 61{,}12 \times (\cos 60°)^{0{,}7} \times \tan 60° \times 27^{2/3} \times 7{,}5^{1{,}8} = 28\ 663$$

According to equation (5)

$$C_{aa} = C_a = 28\ 700\ \text{N}$$

Bibliography

[1] ISO 76:1987, *Rolling bearings — Static load ratings.*