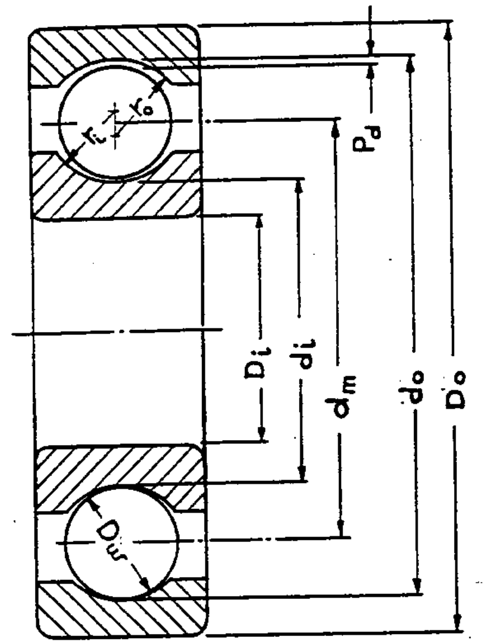
EXAMPLE 2.1 Pitch Diameter and Clearance in Deep-Groove Ball Bearing

Problem Statement



A 209 DGBB has the following dimensions & loading:

- Inner raceway diameter d_i = 52.292 mm
- Outer raceway diameter d_o = 77.706 mm
- D = ball diameter = 12.7 mm
- $r_i = r_o$ = inner and outer raceway groove radii = 6.6 mm
- Z = number of balls = 9

Find values for the:

- Bearing pitch diameter
- Diametral clearance

Problem Solution

Eq. (2.2) $$d_m = \frac{1}{2}(d_i + d_o) = \frac{1}{2}(52.3 + 77.7) = 65mm$$

Eq. (2.3) $$P_d = d_o - d_i - 2D = 77.706 - 52.291 - 2 \cdot 12.7 = 0.015mm$$

EXAMPLE 2.2 Osculations in a Ball Bearing

Problem Statement

Determine the ball-inner raceway and ball-outer raceway osculations for the 209 DGBB of Example 2.1.

Problem Solution

$$f_i = f_o = \frac{r_i}{D} = \frac{r_o}{D} = \frac{6.6}{12.7} = 0.52$$

Eq. (2.5) $$\phi_i = \phi_o = \frac{1}{2f_i} = \frac{1}{2f_o} = \frac{1}{2 \cdot 0.52} = 0.962$$

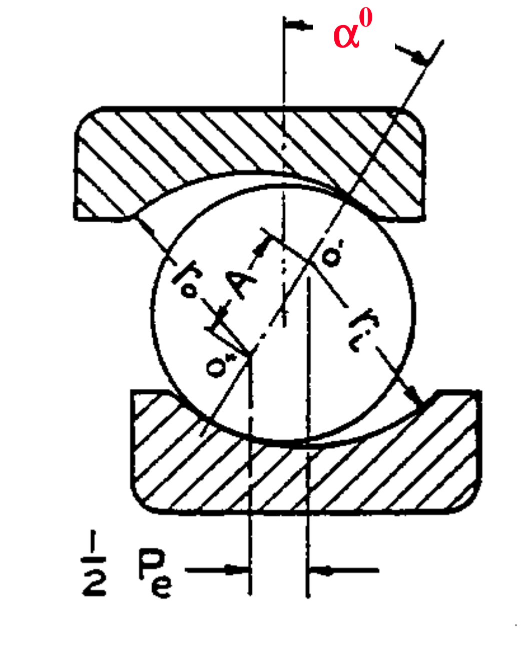
EXAMPLE 2.3 Free Contact Angle in an Angular-Contact Ball Bearing

Problem Statement

A 218 ACBB has the following dimensions:

- Inner raceway diameter d_{i} = 102.79 mm
- Outer raceway diameter d_{io} = 147.73 mm
- D = ball diameter = 22.23 mm
- $r_{\mathrm{i}} = r_{\mathrm{o}}$ = inner & outer raceway groove radii = 11.63 mm

Determine the free contact angle of the bearing.



Problem Solution

$$f_i = f_o = \frac{r_i}{D} = \frac{r_o}{D} = \frac{11.63}{22.23} = 0.5232$$

$$B = f_i + f_o - 1 = 0.5232 + 0.5232 - 1 = 0.0464$$

Eq. (2.3) $$P_d = d_o - d_i - 2D$$

$$P_d = 147.73 - 102.79 - 2 \cdot 22.23 = 0.48mm$$

Eq. (2.7) $$A = BD = 0.0464 \cdot 22.23 = 1.031mm$$

Eq. (2.9) $$\alpha^0 = \cos^{-1}\left(1 - \frac{P_d}{2A}\right)$$

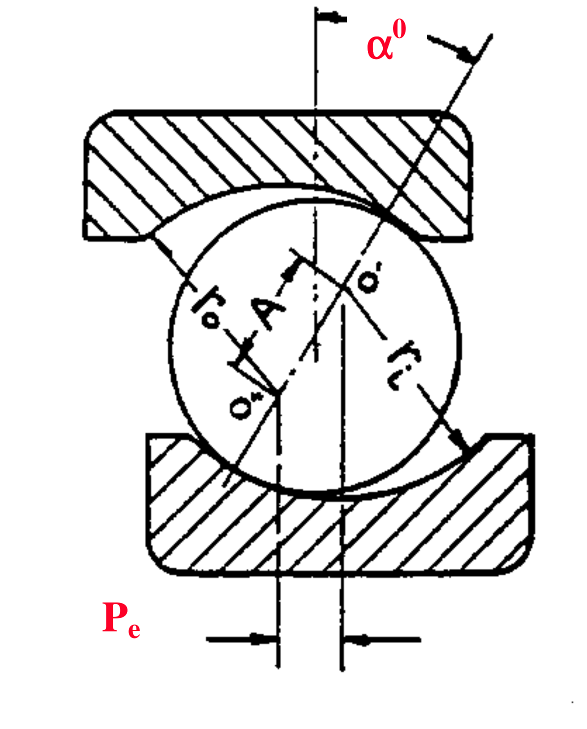
$$\alpha^0 = \cos^{-1}\left(1 - \frac{0.48}{2 \cdot 1.031}\right) = 40°$$

EXAMPLE 2.4 Free Endplay and Free Angle of Misalignment in a Ball Bearing

Problem Statement

Determine the free contact angle, free endplay and free angle of misalignment for the 209 DGBB of Example 2.1.

Problem Solution



$$B = f_i + f_o - 1 = 0.52 + 0.52 - 1 = 0.04$$

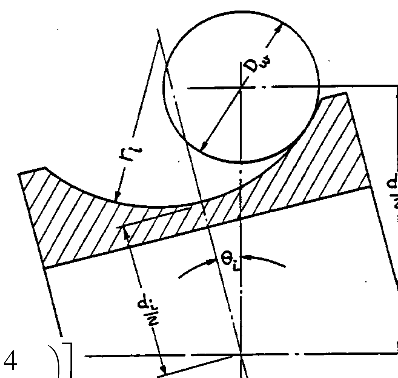
Eq. (2.7) $A = BD = 0.04 \cdot 12.7 = 0.508mm$

Eq. (2.9) $\alpha^0 = \cos^{-1}\left(1 - \frac{P_d}{2A}\right)$

$$\alpha^0 = \cos^{-1}\left(1 - \frac{0.015}{2 \cdot 0.508}\right) = 9°52'$$

Eq. (2.12) $P_e = 2A\sin\alpha^0$

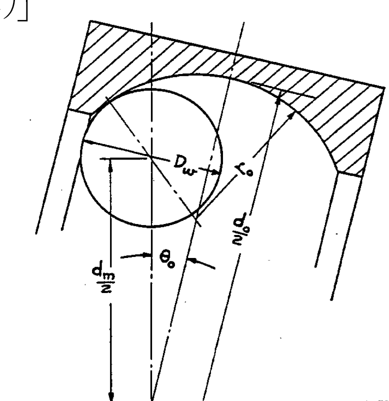
$$P_e = 2 \cdot 0.508 \cdot \sin(9°52') = 0.174mm$$



Eq.(2.23)

$$\theta = 2\cos^{-1}\left[1 - \frac{P_d}{4d_m}\left(\frac{(2f_i - 1)D - P_d/4}{d_m + (2f_i - 1)D - P_d/2} + \frac{(2f_o - 1)D - P_d/4}{d_m - (2f_o - 1)D + P_d/2}\right)\right]$$

$$\theta = 2\cos^{-1}\left[1 - \frac{0.015}{4 \cdot 65}\left(\frac{(2 \cdot 0.52 - 1) \cdot 12.7 - 0.015/4}{65 + 0.04 \cdot 12.7 - 0.015/2} + \frac{0.04 \cdot 12.7 - 0.015/4}{65 - 0.04 \cdot 12.7 + 0.015/2}\right)\right]$$



$$\theta = 9'20''$$

EXAMPLE 2.5 Curvature Sum and Curvature Difference in a Deep-Groove Ball Bearing

Problem Statement

Determine the curvature sum & curvature difference for the 209 DGBB of Example 2.1

Problem Solution

Eq. (2.27) $$\gamma = \frac{D}{d_m}\cos\alpha = \frac{12.7}{65}\cdot\cos(0°) = 0.1954$$

Inner raceway contact

Eq.(2.28) $$\Sigma\rho_i = \frac{1}{D}\left(4 - \frac{1}{f_i} + \frac{2\gamma}{1-\gamma}\right) = \frac{1}{12.7}\left(4 - \frac{1}{0.52} + \frac{2\cdot 0.1954}{1-0.1954}\right) = 0.202mm^{-1}$$

Eq.(2.29) $$F(\rho)_i = \frac{\frac{1}{f_i} + \frac{2\gamma}{1-\gamma}}{D\Sigma\rho_i} = \frac{\frac{1}{0.52} + \frac{2\cdot 0.1954}{1-0.1954}}{12.7\cdot 0.202} = 0.9399$$

Outer raceway contact

Eq.(2.30) $$\Sigma\rho_o = \frac{1}{D}\left(4 - \frac{1}{f_o} - \frac{2\gamma}{1+\gamma}\right) = \frac{1}{12.7}\left(4 - \frac{1}{0.52} - \frac{2\cdot 0.1954}{1+0.1954}\right) = 0.1378mm^{-1}$$

Eq.(2.31) $$F(\rho)_o = \frac{\frac{1}{f_o} - \frac{2\gamma}{1+\gamma}}{D\Sigma\rho_o} = \frac{\frac{1}{0.52} - \frac{2\cdot 0.1954}{1+0.1954}}{12.7\cdot 0.1378} = 0.9120$$

$$F(\rho)_o < F(\rho)_i$$

EXAMPLE 2.6 Curvature Sum and Curvature Difference in an Angular-Contact Ball Bearing

Problem Statement

Determine the curvature sum & curvature difference for the 218 ACBB of Example 2.3.

Problem Solution

Eq. (2.2) $$d_m = \frac{1}{2}(d_i + d_o) = \frac{1}{2}(102.79 + 147.73) = 125.26$$

Eq. (2.27) $$\gamma = \frac{D}{d_m}\cos\alpha = \frac{22.23}{125.26}\cdot\cos(40°) = 0.1359$$

Inner raceway contact

Eq.(2.28) $$\Sigma\rho_i = \frac{1}{D}\left(4 - \frac{1}{f_i} + \frac{2\gamma}{1-\gamma}\right) = \frac{1}{22.23}\left(4 - \frac{1}{0.5232} + \frac{2\cdot 0.1359}{1-0.1359}\right) = 0.108 mm^{-1}$$

Eq.(2.29) $$F(\rho)_i = \frac{\frac{1}{f_i} + \frac{2\gamma}{1-\gamma}}{D\Sigma\rho_i} = \frac{\frac{1}{0.5232} + \frac{2\cdot 0.1359}{1-0.1359}}{22.23\cdot 0.108} = 0.9260$$

Outer raceway contact

Eq.(2.30) $$\Sigma\rho_o = \frac{1}{D}\left(4 - \frac{1}{f_o} - \frac{2\gamma}{1+\gamma}\right) = \frac{1}{12.7}\left(4 - \frac{1}{0.5232} - \frac{2\cdot 0.1359}{1+0.1359}\right) = 0.0832\ mm^{-1}$$

Eq.(2.31) $$F(\rho)_o = \frac{\frac{1}{f_o} - \frac{2\gamma}{1+\gamma}}{D\Sigma\rho_o} = \frac{\frac{1}{0.5232} - \frac{2\cdot 0.1359}{1+0.1359}}{22.23\cdot 0.0832} = 0.9038$$

$$F(\rho)_o < F(\rho)_i$$

EXAMPLE 2.7 Free Endplay in a Spherical Roller Bearing

Problem Statement

A 22317 SRB has the following dimensions & loading:

- Inner raceway contour radius r_i = 81.585 mm
- Outer raceway contour radius r_o = 81.585 mm
- D = roller diameter = 25 mm
- Roller contour radius R = 79.959 mm
- Z = no. roller per row = 14
- Roller effective length l = 20.762 mm
- Bearing pitch diameter d_m = 135.077
- Nominal contact angle α = 12°
- Diametral play S_d = 0.102 mm

Find value for endplay P_e

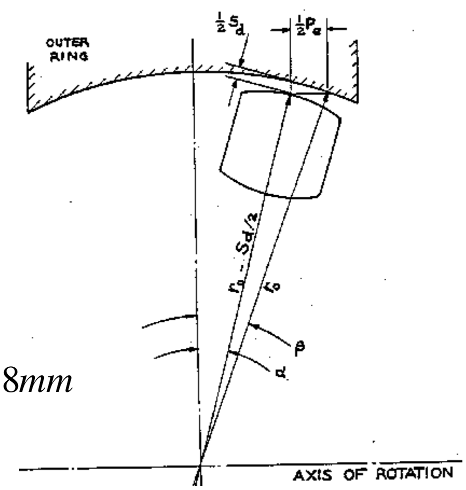
Problem Solution

Eq. (2.34) $$\beta = \cos^{-1}\left[\left(1 - \frac{S_d}{2r_o}\right)\cos\alpha\right]$$

$$\beta = \cos^{-1}\left[\left(1 - \frac{0.102}{2 \cdot 81.585}\right)\cos 14°\right] = 12.17°$$

Eq. (2.35) $$P_e = 2r_o(\sin\beta - \sin\alpha) + S_d \sin\alpha$$

$$P_e = 2 \cdot 85.585(\sin 12.17° - \sin 12°) + 0.102 \sin 12° = 0.5178 mm$$

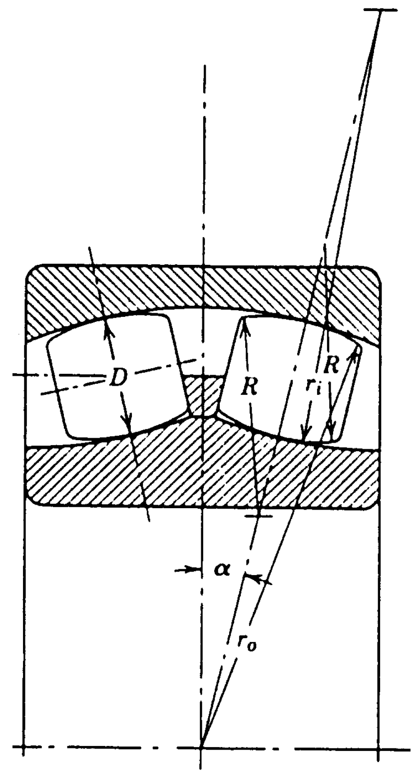


EXAMPLE 2.8 Osculations in a Spherical Roller Bearing

Problem Statement

Determine the values for the inner and outer raceway contact osculations for the 22317 SRB of Example 2.7.

Problem Solution



Eq. (2.36)

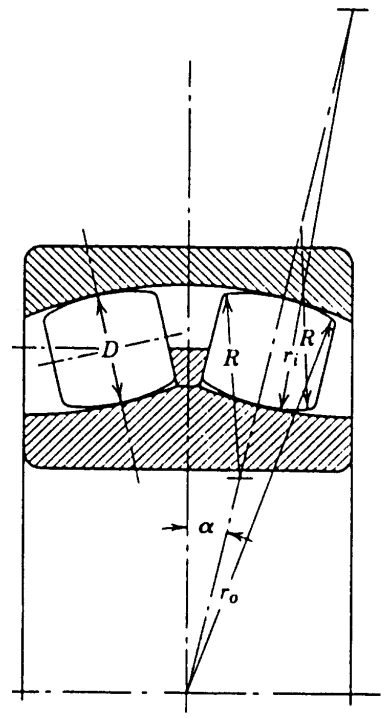
$$\phi_i = \phi_o \frac{R}{r_i} = \frac{79.959}{81.585} = 0.98$$

EXAMPLE 2.9 Curvature Parameters in a Spherical Roller Bearing

Problem Statement

Determine the values of curvature sum & curvature difference for the inner and outer raceway contacts of the 22317 SRB of Example 2.7.

Problem Solution



Eq. (2.27) $$\gamma = \frac{D}{d_m}\cos\alpha = \frac{25}{135.1}\cdot\cos(12°) = 0.1810$$

Eq. (2.37) $$\Sigma\rho_i = \frac{1}{D}\left[\frac{2}{1-\gamma} + D\left(\frac{1}{R} - \frac{1}{r_i}\right)\right]$$

$$\Sigma\rho_i = \frac{1}{25}\left[\frac{2}{1-0.181} + 25\left(\frac{1}{79.959} - \frac{1}{81.585}\right)\right] = 0.09793 mm^{-1}$$

Eq. (2.39) $$\Sigma\rho_o = \frac{1}{D}\left[\frac{2}{1+\gamma} + D\left(\frac{1}{R} - \frac{1}{r_i}\right)\right]$$

$$\Sigma\rho_o = \frac{1}{25}\left[\frac{2}{1+0.181} + 25\left(\frac{1}{79.959} - \frac{1}{81.585}\right)\right] = 0.068 mm^{-1}$$

Eq. (2.38) $$F(\rho)_i = \frac{\dfrac{2}{1-\gamma} - D\left(\dfrac{1}{R} - \dfrac{1}{r_i}\right)}{\dfrac{2}{1-\gamma} + D\left(\dfrac{1}{R} - \dfrac{1}{r_i}\right)}$$

$$F(\rho)_i = \frac{\dfrac{2}{1-0.181} - 25\left(\dfrac{1}{79.959} - \dfrac{1}{81.585}\right)}{\dfrac{2}{1-0.181} + 25\left(\dfrac{1}{79.959} - \dfrac{1}{81.585}\right)} = 0.9951$$

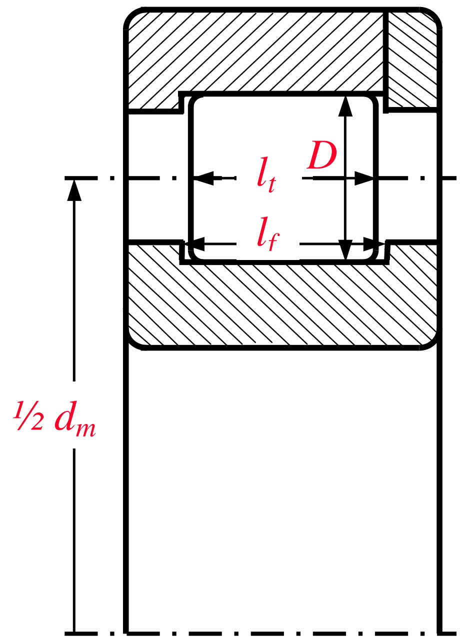
Eq. (2.40)

$$F(\rho)_o = \frac{\dfrac{2}{1+\gamma} - D\left(\dfrac{1}{R} - \dfrac{1}{r_i}\right)}{\dfrac{2}{1+\gamma} + D\left(\dfrac{1}{R} - \dfrac{1}{r_i}\right)}$$

$$F(\rho)_o = \frac{\dfrac{2}{1+0.181} - 25\left(\dfrac{1}{79.959} - \dfrac{1}{81.585}\right)}{\dfrac{2}{1+0.181} + 25\left(\dfrac{1}{79.959} - \dfrac{1}{81.585}\right)} = 0.9929$$

EXAMPLE 2.10 Pitch Diameter and Clearance in a Cylindrical Roller Bearing

Problem Statement



A 209 CRB has the following dimensions & loading:

- Inner raceway diameter d_i = 54.991 mm
- Outer raceway diameter d_o = 75.032 mm
- D = roller diameter = 10 mm
- Z = no. rollers = 14
- Roller effective length l = 9.601 mm
- Roller total length l_t = 10 mm

Find values for:

- Bearing pitch diameter d_m
- Diametral clearance P_d

Eq. (2.2) $$d_m = \frac{1}{2}(d_i + d_o) = \frac{1}{2}(54.991 + 75.032) = 65.011 mm$$

Eq. (2.3) $$P_d = d_o - d_i - 2D = 75.032 - 54.991 - 2 \cdot 10 = 0.041 mm$$