Bearing Selection: Combined Radial & Thrust Load Example

Problem Statement

Select a single-row radial Conrad type bearing to carry a 2250 N radial load and a 1350 N thrust load at 1725 RPM for a machine expected to run an 8-hour shift, but not fully utilized, with light impact and 95% reliability.

Solution

• The suggested design life is obtained from J&M Table 14.4: \( \approx 14,000-20,000 \) hours.

• Load factor for light impact is obtained from J&M Table 14.3: \( \approx 1.4 \).

• Try 200-series (light) bearing for the first iteration.

• We will make the first guess for the bearing load requirement based on the radial load alone:

\[
P_{\text{radial only}} = K_a F_r = 1.4(2250) = 3150 \text{ N}
\]

Applying the load-life equation:

\[
C_E = P \left( \frac{L_n N}{K_f L R n R} \right)^{\frac{1}{3}} = 3150 \text{ N} \left[ \frac{18,000(1725)}{.62(500)(33 1/3)} \right]^{\frac{1}{3}} = 45 \text{ kN}
\]

A 55 mm bore bearing is the first in the 200K series which exceeds this rating. Since we ignored the thrust load, we will make a first guess of a bearing with a 60 mm bore (Timken 212K).

• Now that we’ve tentatively selected a bearing, we can properly account for the thrust load. The ratings for the 212K bearing are:

\[
C_O = 35.5 \text{ kN} \quad C_E = 61.1 \text{ kN}
\]

\[
\frac{T}{C_O} = \frac{1350}{35,500} = .0380
\]

Estimating from Timken Table 6 (p. A30)\(^1\):

\[
Y_1 \approx 1.9
\]

From Timken Table 5 (p. A30), for 200-series bearing:

\[
\begin{aligned}
F_e &= R \\
F_e &= .56R + Y_1 F_d
\end{aligned}
\]

\( \) (whichever is larger)

\(^1\) A more exact number could be obtained using linear interpolation, but this probably isn’t warranted during the first iteration.
Note: Timken’s $P$ in Table 5 is our $F_e$; i.e., the load before correction for shock loading.

\[
F_e = .56(2250) + 1.9(1350) = 3825
\]

Since this value is larger than the radial load alone, this is the one that we should use for sizing the bearing.

Now correct for light impact:

\[
P = K_aF_e = 1.4(3825) = 5355 \text{ N}
\]

We can now estimate the design life:

\[
L_n = \frac{n_R}{N} L_R K_r \left( \frac{C_E}{P} \right)^3 = \frac{33}{1725} \frac{1}{3} (500 \text{ hrs})(.62) \left( \frac{58.5}{5.355} \right)^3 = 7810 \text{ hrs}
\]

This is substantially low! Therefore, we must try again with a larger bearing.

- Try an 80 mm bore:

\[
C_O = 54.2 \text{ kN} \quad C_E = 81.3 \text{ kN} \quad \frac{T}{C_O} = 0.024
\]

Interpolating in Timken Table 6:

\[
\frac{Y_1 - 2.22}{.024 - .020} = \frac{2.10 - 2.22}{0.025 - 0.020} \Rightarrow Y_1 = 2.12
\]

\[
P = 1.4[0.56(2250 \text{ N}) + 2.12(1350 \text{ N})] = 5.77 \text{ kN}
\]

\[
L_n = \frac{33}{1725} \frac{1}{3} (500 \text{ hrs})(.62) \left( \frac{81.3}{5.77} \right)^3 = 16,700 \text{ hrs}
\]

Therefore, if a 200-series bearing is used, a 216K bearing (80 mm ID, 140 mm OD, 26 mm width) should be specified.

- If a smaller shaft size is desired, we could try moving to a 300-series bearing:

Try Timken 311K:

\[
ID = 55 \text{ mm} \quad OD = 120 \text{ mm} \quad C_O = 44.4 \text{ kN} \quad C_E = 81.2 \text{ kN}
\]

\[
K_T = \frac{T}{C_O} = 0.0304 \Rightarrow Y_1 = 1.94 \text{ (interpolating in Timken Table 6)}
\]

\[
F_e = .56(2250) + 1.94(1350) = 3879 \text{ N}
\]

\[
P = K_aF_e = 1.4(3879 \text{ N}) = 5430 \text{ N}
\]

\[
L_n = \frac{16700(.62)}{1725} \left( \frac{81.200}{5430} \right)^3 = 20,000 \text{ hrs}
\]

Looks good!

The shaft diameter of the 311K bearing is 25 mm less than the 216K bearing. The housing bore is 20 mm less. The 311K bearing is 3 mm wider than the 216K bearing.