11-2/. ball bearing

$F_D = 4 KN$ $\quad$ $F_R = ?$

$L_D = 1200 h$ $\quad$ $L_R = 3800 h$

$n_D = 600$ rev/min $\quad$ $n_R = 500$ rev/min

$a = 3$ for ball bearing.

Eq 11-4,

$$F_R = F_D \left(\frac{L_D n_D}{L_R n_R} \right)^{1/a}$$

$$= (4 KN) \left(\frac{1200h \times 600 \text{ rev/min}}{3800h \times 500 \text{ rev/min}} \right)^{1/3}$$

$$= (4 KN)(0.723)$$

$$= 2.894 KN$$

∴ bearing selected to satisfy this design must have have a catalog radial load rating equal or greater than 2.89 KN //.

11-6/ 02-series to be selected

$F_r = 8\,KN$ (applied radial load)

$F_a = 4\,KN$ (applied thurst load)

Pg 456:

$L_{10} = (5000)(900)(60\ min/h)$

$= 270 \times 10^6$ rev.

Try $Fe_1 = 9\,KN$ 02-series deep groove

∴ Eq 11-3, $C = FL^{1/a}$ $a = 3$ (ball bearing)

$= 9(270)^{1/3}$

$= 58\,KN$

From table 11-3, 70 mm give $C = 61.8$ (choose this one)

$\Rightarrow C_o = 37.5\,KN$

use table 11-2, $\frac{F_a}{C_o} = \frac{4}{37.5} = 0.107$

from which choose $F_a/C_o = 0.110$ in table

and we get $x = 0.56$, $y = 1.45$

Eq(11-12) ∴ $Fe_2 = 0.56(8) + 1.45(4)$

$= 10.28\,KN$

check: $Fe = Fe_2 - Fe_1 = 1.28\,KN$ (Not converge)

So, continue, use $Fe = Fe_2 = 10.28\,KN$,

Eq 11-3, $C = 10.28(270)^{1/3}$

$= 66.4\,KN$

From table 11-3,

see $C = 66.4$, choose $C = 70.2$ in table 11-3,

corresponding Bore is 80mm, $C_o = 45$ KN

check: $\frac{F_a}{C_o} = \frac{4}{45} = 0.089$

use table 11-2, $X = 0.56$, $Y = 1.53$ (use interpolation between $Y = 1.55$ & $Y = 1.45$)

Extra: Interpolation:

F_a/C_o	Y_2
0.084 →	1.55
0.089 →	? Y_2
0.110 →	1.45

Ans:

$$Y_2 = 1.45 + \left(\frac{0.11 - 0.089}{0.11 - 0.084}\right)(1.55 - 1.45)$$

$$= 1.53$$

again, Eq 11-12,

$$F_e = 0.56(8) + 1.53(4)$$

$$= 10.6 \text{ KN}$$

check: $10.6 - 10.28 = 0.32$ (good for convergence)

$$\therefore C = 10.6(270)^{1/3}$$

$$= 68.5 \text{ KN} \quad //$$

80mm Bore, 02-series, deep-groove

12-1, given : $r = 0.5$ in $\quad \mu = 8\ \mu$reyn

$l/d = 1$ $\quad c = 0.00075$

$N = 1100\ \text{rev/min} \times \frac{1\,\text{min}}{60\,\text{s}} = 18.3\ \text{rev/s}$ $\quad r/c = \frac{0.5}{0.00075} = 667$

$P = 250\,\text{lb}/1\,\text{in}^2 = 250$ psi

Eq 12-7,

$$S = (r/c)^2 \frac{\mu N}{P}$$

$$= (667)^2 \frac{(8\times10^{-6})(18.3)}{250} \cong 0.261$$

use table 12-14, $l/d = 1$

$$h_o/c \cong 0.59$$

use table 12-17, $l/d = 1$

$$\frac{r}{c} f \cong 5.8$$

use table 12-19, $l/d = 1$,

$$\frac{Q_s}{Q} \cong 0.5$$

use table 12-18, $l/d = 1$

$$\frac{Q}{rcNl} \cong 3.98$$

$\Rightarrow h_o = c \times 0.59$

$= 0.00075 \times 0.59 = \underline{0.000446\ \text{in}}$ // (minimum flim thickness)

$\Rightarrow f = 5.8 \times c/r$

$= 5.8/667 = 0.0087$

Pg 504 : $\therefore H = \frac{2\pi f W r N}{778(12)}$ ~ in btu/s $\quad$ ↙ Power lost

$$= \frac{2\pi(0.0087)(250)(0.5)(18.3)}{778(12)} \cong 0.0134\ \text{btu/s}$$ //

$$\Rightarrow \frac{Q}{rcNl} = 3.98$$

$$Q = 3.98(0.5)(0.00075)(18.3)(1)$$

$$= 0.0273 \ in^3/s$$

$$\Rightarrow \frac{Q_s}{Q} = 0.5$$

$$Q_s = 0.5(0.0273) \ in^3/s$$

$$= 0.0137 \ in^3/s \quad // \quad \text{(side flow)}$$

12-17 $N = \frac{1750}{60} = 29.17\ \frac{rev}{s}$ $W = 250$

$r = 0.625''$ $L = 1.25''$ $T_1 = 120°F$

$C_{min} = 0.001 - 0.00025 = 0.00075''$

$C_{max} = 0.001 + 0.00025 = 0.00125''$ OIL : SAE 10

MIN: $P = 160$ $\frac{L}{D} = 1$ $C = 0.00075$ $\frac{R}{C} = 833$

Fig: 12-11 Try $\Delta T = 40°F$ $T_{Av} = 120 + \frac{40}{2} = 120°$

↓ $\mu = 3$ μreyn eq. (12-7) $S = \left(\frac{r}{c}\right)^2 \frac{\mu N}{P} = 0.38$

Fig. 12-17, 18, 19: $\frac{r}{c} f = 8$, $\frac{Q}{rcNL} = 3.8$, $\frac{Q_s}{Q} = 0.42$

Eq.: (12-18) $\Delta T_F = \frac{0.103P}{1 - \frac{1}{2}\left(\frac{Q_s}{Q}\right)} \frac{(r/c)f}{Q/rcNL} = 43.92°$ $T_{Av} = 142°F$

Try: $2.7 = \mu$ $S = 0.3418$

$\frac{r}{c} f = 7$ $\frac{Q}{rcNL} = 4$ $\frac{Q_s}{Q} = 0.45$

$\Delta T_F = 37.21$ $T_o = 139°F$

MAX: $P = 160$ $L/D = 1$ $\frac{R}{C} = 500$ $C = 0.00125$

Try $\Delta T = 20$ $T = 130$ $\mu = 2.8$ $S = .1276$

$\frac{r}{c} f = 2.9$ $\frac{Q}{rcNL} = 4.4$ $\frac{Q_s}{Q} = 0.7$

$\Delta T_F = 16.7$ $T_{Av} = 128.35°$

Try $\mu = 2.4$ $S = .1094$

$\frac{r}{c} f = 2.8$ $\frac{Q}{rcNL} = 4.5$ $\frac{Q_s}{Q} = .75$

$\Delta T = 16.4$

$T_A = 136.4°F$

IF $C_{MIN} = 0.001 - 0.0005 = 0.0005$

AND $C_{MAX} = 0.001 + 0.0005 = 0.0015$

MIN: $P = 160$ $\quad \frac{L}{D} = 1$ $\quad C = 0.0005$ $\quad \frac{r}{c} = 1250$

TRY $\Delta T = 30$ $\quad T = 115$

$\mu = 3.8$ $\quad S = 0.108$

$\frac{r}{c} f = 2.9$ $\quad \frac{Q}{rcNL} = 4.3$ $\quad \frac{Q_s}{Q} = 0.7$ $\quad \Delta T = 17.1$

$T_{AV} = 128.5°F$

TRY $\mu = 2$

$S = .5697$

$\frac{r}{c} f = 10$ $\quad \frac{Q}{rcNL} = 3.6$ $\quad \frac{Q_s}{Q} = 0.3$

$\Delta T = 53.6$ $\quad T_o = 173.8°F$

MAX: $P = 160$ $\quad \frac{L}{D} = 1$ $\quad C = 0.0015$ $\quad \frac{r}{c} = 416$

Try $\Delta T = 40$ $\quad T = 140$ $\quad \mu = 3$ $\quad S = .1465$

$\frac{r}{c} f = 18$ $\quad \frac{Q}{rcNL} = 3.5$ $\quad \frac{Q_s}{Q} = .21$

$\Delta T = 94.7$ $\quad T_{AV} = 167$

Try $\mu = 1.5$

$S = .473$

$\frac{r}{c} f = 8$ $\quad \frac{Q}{rcNL} = 3.6$ $\quad \frac{Q_s}{Q} = .33$

$\Delta T = 43.85$ $\quad T_o = 163.85°F$

(12-12) Diameter = 80 mm $\frac{l}{d} = 1$ $N = 8 \frac{rev}{s}$

oil SAE 30 $T_1 = 60°C$ $W = 3000\ N$ $C = 0.04\ mm$

Find ΔT, h_0, Heat Loss, Q_s

$N = 8 \frac{rev}{s}$ $W = 3000\ N$ $r = 40\ mm$

$C = 0.04\ mm$ $L = 80\ mm$ $T_1 = 60°C$

$P = \frac{3000}{80^2} = 0.469\ MPa$

Fig. 12-12 (1) Try $\mu = 12\ MPa\text{-}s \rightarrow T_{av} = 81°C$

$\Delta T_1 = 2(81-60) = 42°$

$S = \left(\frac{r}{c}\right)^2 \frac{\mu N}{P} = 0.2047$

Fig 12-17, 18, 19 $\frac{r}{c} f = 4.6$ $\frac{Q}{rcNl} = 4.1$ $\frac{Q_s}{Q} = 0.56$

Eq. (12-19) $\Delta T_2 = \frac{8.30\,P}{1 - \frac{1}{2}\frac{Q_s}{Q}} \frac{\frac{r}{c} f}{\frac{Q}{rcNl}} = 6.07°C$

$\Delta T_2 - \Delta T_1 = 36°C$

(2) Try $\mu = 20\ MPa\text{-}s$ $T_{av} = 68°C$

$\Delta T_3 = 2(68-60) = 16°C$

$S = 0.341$ $\frac{r}{c} f = 7.2$ $\frac{Q}{rcNl} = 3.86$ $\frac{Q_s}{Q} = 0.43$

$\Delta T_4 = 9.25$

$\Delta T_4 - \Delta T_3 = 6.75°C$

(3) Try $\mu = 21$ $T = 65°C$ $\Delta T_5 = 2(65-60) = 10°C \leftarrow \Delta T$

$S = 0.358$ $\frac{r}{c} f = 7.5$ $\frac{Q}{rcNl} = 3.83$ $\frac{Q_s}{Q} = 0.415$

$\Delta T_6 = 9.62°C$ $\Delta T_6 - \Delta T_5 = 0.38°C$ FINE

$\frac{h_0}{c} = 0.67 \rightarrow h_0 = 0.0268\ mm$ $f = \frac{7.25}{\frac{40}{.04}} = 0.0075$ $H = 2\pi f W N r$

$\Delta T = 10°C$

$\frac{h_o}{c} = 0.67$ (Fig 12-14) $h_o = (0.67)(.04) = 0.0268$ mm

$\frac{r}{c} f = 7.5$ $f = 7.5 \frac{c}{r} = 0.0075$

$T = fWr = 0.9$

$H = 2\pi TN = 45.2$

$\frac{Q_s}{Q} = 0.415$ $\frac{Q}{rcNl} = 3.83$

$Q = 3.83\, rcNl = 3922$

$Q_s = 0.415\, Q = 1628 \frac{mm^3}{s}$

(12-17) $N = \frac{1750}{60} = 29.17 \frac{rev}{s}$ $W = 250$ $r = 0.625''$

$L = 1.25''$ $T_1 = 120°F$ SAE 10

$C_{min} = 0.001 - 0.00025 = 0.00075$ in.

$C_{max} = 0.001 + 0.00025 = 0.00125$ in.

Find outlet temp for extremes of clearance

$P = \frac{250}{1.25^2} = 160$ $\frac{l}{d} = 1$ $\frac{r}{c} =$

min: $\frac{r}{c} = 833.33$ $S = \left(\frac{r}{c}\right)^2 \frac{\mu N}{P} = .126604\,\mu$

Try $\mu = 2$ $S = 0.253208$

Fig 12-17, 18, 19 : $\frac{r}{c}f = 6$ $\frac{Q}{rcNl} = 3.9$ $\frac{Q_s}{Q} = 0.5$

$\Delta T = \frac{0.103\,P\,\frac{r}{c}f}{Q/rcNl} = 25.4°F$

$T_o = T_i + \Delta T = \underline{145.4°F}$

MAX: $\frac{r}{c} = 500$ $c = .00125$

Try $\mu = 2.6$ $S = .045578\,\mu$

$S = .118$

Fig 12-17, 18, ~~19~~ $\frac{r}{c}f = 3$ $\frac{Q}{rcNl} =$ ~~0.7~~ 4.4

$\Delta T = \frac{.103\,P\,\frac{r}{c}f}{Q/rcNl} = 11.24$

$T_o = T_i + 11.24 = \underline{131.24°F}$

NOTE: SHOULD ITERATE UNTIL CONVERGENCE AS IN 12-7