Read all problems carefully. Check the board for any additions or corrections.

Show all work, which must be neat and orderly to be graded. That is, sloppy work will not be graded!

Show no work on this page. Return this page with your solutions.

1. A sliding element bearing has an L/d ratio of 1, a diameter of 3.00 inch, a load of 600 pounds, corresponding to a rotational speed of 750 rpm. The lubricant is SAE 20 oil at a temperature of 145°F. Determine the temperature rise across the bearing, the supply and outlet oil temperatures, coefficient of friction, eccentricity, total and side oil flows, maximum oil pressure, and the power lost in the bearing. Use a radial clearance ratio of 750.

2. For the design of problem (1) select a rolling element bearing which has a reliability of 90% and must last for 25,000 hours. The application is light impact.

3. For the figure shown below, verify the free body diagram is correct.

4. A bearing has been operated at 500,000 cycles at 10,000-N. Can this bearing be operated at 25,000-N for an additional 250,000 cycles? The bearing is an 02 series with a bore diameter of 40-mm.
\( d = 3.00 \text{ in} \)
\( b/d = 1 \)
\( l = 3.00 \text{ in} \)
\( W = 600\text{lbf} \)
\( f/C = 750 \)
\( N = 750 \text{ rev/min} \times \frac{1\text{ min}}{60\text{ sec}} = 12.5 \text{ rev/sec} \)
\( SAE 20 \)
\( T_{avg} = 145^\circ \text{F} \rightarrow M = 2.6 \text{ in revn} \)

**FIRST, THE SOMMERFİELD NUMBER:**

\[
S = \left( \frac{f}{C} \right)^2 \left( \frac{MN}{P} \right) = \left( \frac{750}{66.7 \text{ psi}} \right)^2 \left( \frac{2.6 \times 10^{-6} \text{ revn}(12.5 \text{ rev/sec})}{66.7 \text{ psi}} \right) = 0.27
\]

**NOW THE TEMPERATURE RISE:**

\[
\Delta T_F = \frac{0.103P}{1-0.5 \frac{Qs}{Q}} \frac{\frac{\epsilon f}{Q}}{\frac{\epsilon f}{Q}} = \frac{0.103(66.7)}{1-0.5(145)} \frac{16}{3.8} = 14^\circ \text{F}
\]

**INS & OUT TEMPS:**

\( T_i = T_{avg} - \frac{1}{2} \Delta T = 145^\circ \text{F} - \frac{1}{2}(14^\circ \text{F}) = 138^\circ \text{F} \)

\( T_o = T_{avg} + \frac{1}{2} \Delta T = 145 + 7 = 152^\circ \text{F} \)

**COEFFICIENT OF FRICTION:**

\[
\frac{\epsilon f}{Q} = 6 \rightarrow F = \frac{6}{750} = 0.008
\]

**ECCENTRICITY:**

\[
\xi = 0.38 \rightarrow e = \xi f = 0.38 \left( \frac{1.5 \text{ in}}{750} \right) = 0.00076 \text{ in}
\]
TOTAL & SIDE FLOWS:

\[ \frac{Q}{rcN_e} = 3.8 \Rightarrow Q = 3.8 \left( \frac{1.5\text{ in}}{750} \right) \left( \frac{12.5 \text{ rev}}{\text{sec}} \right) (3.0 \text{ in}) = 0.43 \text{ in}^3/\text{sec} \]

\[ \frac{Q_s}{Q} = 0.45 \Rightarrow Q_s = 0.45 (0.43 \text{ in}^3/\text{sec}) = 0.19 \text{ in}^3/\text{sec} \]

MAX OIL PRESSURE:

\[ \frac{P}{P_{\text{max}}} = 0.48 \Rightarrow P_{\text{max}} = \frac{66.7 \text{ psi}}{0.48} = 139 \text{ psi} \]

POWER COST:

\[ H_p = \frac{F \omega r N}{1050} = \frac{0.008 (600 \text{ lb}) (1.5 \text{ in}) (12.5 \text{ rev/} \text{sec})}{1050} \]

\[ = 0.086 \text{ hp} \]

ROLLING ELEMENT BEARING

RELIAB = 90% \Rightarrow K_R = 1.0

25,000 \text{ hr/yr} \times 750 \text{ rev/yr} \times 60 \text{ min/rev} = 1,125 \text{ E8 cycles/yr}

LIGHT IMPACT \Rightarrow K_a = 1.3 \text{ (BALL BEARING)}

\[ C_{\text{req}} = K_a F_c \left( \frac{L}{K_r L_R} \right)^{0.3} = 1.3 (600 \text{ lb}) \left( \frac{1.125 \text{ E8}}{1.6 (90 \text{ E6})} \right)^{0.3} = 1664 \text{ lb} \]

\[ = 7.4 \text{ kN} \]

CHOOSE 55mm L11 OR LARGER

\text{OR} 35mm 207 OR LARGER \{ \text{RADIAL BALL} \}

\text{OR} 30mm 306 OR LARGER

\text{OR} 55mm L11 OR LARGER \{ \text{ANGULAR BALL} \}

\text{OR} 35mm 207 OR LARGER

\text{OR} 30mm 306 OR LARGER

\text{SHAFT} = 3.0 \text{ in dia} \Rightarrow \boxed{76.2 \text{ mm}}

Ø 0.116 is BEST
3. \( \Sigma F_x = 0 \\
\Sigma F_y = 409.1 + 1090.9 - 1500 = 0 \\
\Sigma F_z = 0 \\
\Sigma M_x = 7500 - 7500 = 0 \\
\Sigma M_y = 0 \\
\Sigma M_z = -1500(6) + 409.1(22) = 0 \\
\text{YUP, IT'S IN EQUILIBRIUM} \\
\left[ \text{Note:} \frac{0.2 \text{ in}-\text{lb}}{9000 \text{ in}-\text{lb}} = 0.002\% \text{ OFF} \right]

4. \( \frac{l_1 + l_2}{l_1} \leq 1 \implies l_2 \leq \left(1 - \frac{l_1}{l_2}\right) L_2 \)

\( L_1 = 1 \text{EG} \left(\frac{30.7 \text{ kN}}{10 \text{ kN}}\right)^{3.33} = 4.2 \text{ EG} \)

\( L_2 = 1 \text{EG} \left(\frac{30.7 \text{ kN}}{25 \text{ kN}}\right)^{3.33} = 2.0 \text{ EG} \)

\( l_2 \leq 1.98 \text{ EG} \implies \text{NEW LOAD OK.} \)

\( L_1 = 1 \text{EG} \left(\frac{31.9}{10}\right)^{3.33} = 4.8 \text{ EG} \)

\( L_2 = 1 \text{EG} \left(\frac{31.9}{25}\right)^{3.33} = 2.3 \text{ EG} \)

\( l_2 \leq 2.3 \text{ EG} \implies \text{NEW LOAD OK.} \)