ME-340 EXAM - 02 *November 12, 1998*

*NAME:*______________________ *8:00 AM*

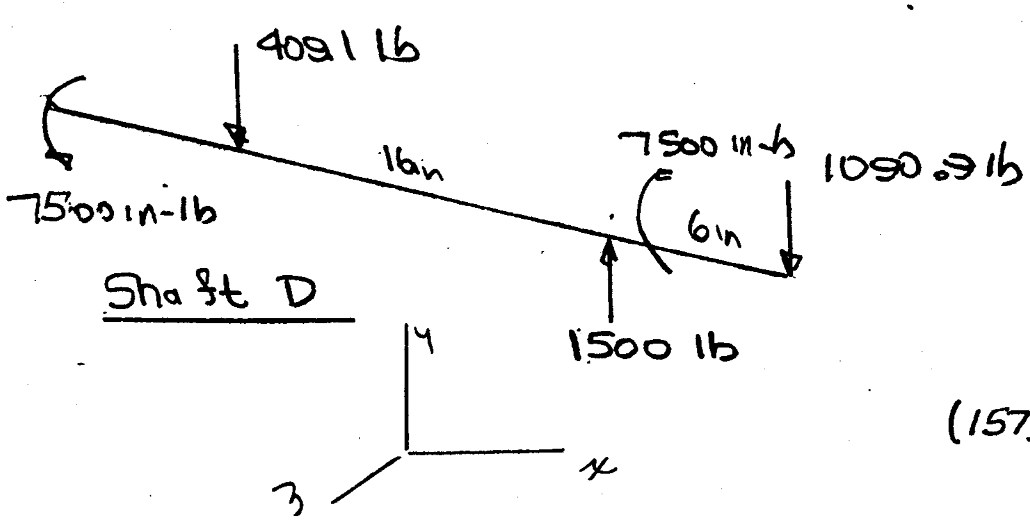
- *Read all problems carefully. Check the board for any additions or corrections.*
- *Show all work, which must be neat and orderly to be graded. That is ,sloppy work will not be graded!*
- *Show no work on this page. Return this page with your solutions.*

(1) A sliding element bearing has an L/d ratio of 1, a diameter of 3.00 inch, a load of 600pounds, corresponding to a rotational speed of 750 rpm. The lubricant is SAE 20 oil at a temperature of 145F. 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.



(157)

① $d = 3.00\text{ in}$

$l/d = 1$

$l = 3.00\text{ in}$

$W = 600\text{ lb}$

$\left.\right\} \rightarrow P = \frac{W}{ld} = \frac{600\text{ lb}}{9\text{ in}^2} = 66.7\text{ psi}$

$\frac{r}{c} = 750$

$N = 750\ \frac{\text{rev}}{\text{min}} \times \frac{1\text{ min}}{60\text{ sec}} = 12.5\text{ rev/sec}$

SAE 20

$T_{AVG} = 145°F \rightarrow \mu = 2.6\ \mu\text{ reyn}$

FIRST, THE SOMMERFIELD NUMBER:

$$S = \left(\frac{r}{c}\right)^2\left(\frac{\mu N}{P}\right) = (750)^2\left(\frac{2.6\times10^{-6}\text{ reyn}(12.5\text{ rev/sec})}{66.7\text{ psi}}\right)$$

$$= 0.27$$

NOW THE TEMPERATURE RISE:

$$\Delta T_F = \frac{0.103P}{1-0.5\frac{Q_s}{Q}}\ \frac{\frac{r}{c}f}{\frac{Q}{rcNl}} = \frac{0.103(66.7)}{1-0.5(.45)}\ \frac{6}{3.8} = 14°\ F$$

IN & OUT TEMPS:

$$T_i = T_{AVG} - \tfrac{1}{2}\Delta T = 145°F - \tfrac{1}{2}(14°F) = 138°F$$

$$T_o = T_{AVG} + \tfrac{1}{2}\Delta T = 145 + 7 = 152°F$$

COEFFICIENT OF FRICTION:

$$\frac{r}{c}f = 6 \rightarrow F = \frac{6}{750} = 0.008$$

ECCENTRICITY:

$$\varepsilon = 0.38 \rightarrow e = \varepsilon c = 0.38\left(\frac{1.5\text{ in}}{750}\right) = 0.00076\text{ in}$$

EXAM #2 – BEARINGS CONT'D
TEST CODE 157

(1) CONT'D

TOTAL & SIDE FLOWS:

$$\frac{Q}{rcNl} = 3.8 \rightarrow Q = 3.8(1.5\,in)\left(\frac{1.5\,in}{750}\right)12.5\,\frac{rev}{sec}(3.0\,in) = 0.43\,in^3/sec$$

$$\frac{Q_s}{Q} = 0.45 \rightarrow Q_s = 0.45(0.43\,in^3/sec) = 0.19\,in^3/sec$$

MAX OIL PRESSURE:

$$\frac{P}{P_{max}} = 0.48 \rightarrow P_{max} = \frac{66.7\,psi}{0.48} = 139\,psig$$

POWER LOST:

$$H_p = \frac{fWrN}{1050} = \frac{0.008(600\,lb)\,1.5\,in\,(12.5\,\frac{rev}{sec})}{1050}$$
$$= 0.086\,hp$$

(2) ROLLING ELEMENT BEARING

RELIAB = 90% → $K_R = 1.0$

25,000 hrs × 750 rev/min × 60 min/hr = 1.125 E9 CYCLES

LIGHT IMPACT → $k_a = 1.3$ (BALL BEARING)

$$C_{REQ} = k_a F_e \left(\frac{L}{K_R L_R}\right)^{0.3} = 1.3(600\,lb)\left(\frac{1.125\,E9}{(1.0)\,90\,E6}\right)^{0.3} = 1664\,lb$$
$$= 7.4\,kN$$

CHOOSE 55mm L11 OR LARGER
OR 35 mm 207 OR LARGER
OR 30 mm 306 OR LARGER
} RADIAL BALL

OR 55 mm L11 OR LARGER
OR 35 mm 207 OR LARGER
OR 30 mm 306 OR LARGER
} ANGULAR BALL

SHAFT = 3.0 in dia
= 76.2 mm
∴ L16 IS BEST

EXAM #2 – BEARINGS CONT'D
TEST CODE 157

(3)
$\Sigma F_x = 0$

$\Sigma F_y = 409.1 + 1090.9 - 1500 = 0$

$\Sigma F_z = 0$

$\Sigma M_x = 7500 - 7500 = 0$

$\Sigma M_y = 0$

$\Sigma M_z = -1500(6) + 409.1(22) = 0$

YUP, IT'S IN EQUILLIBRIUM

[NOTE: $\frac{0.2 \text{ in-lb}}{9000 \text{ in-lb}} = 0.002\%$ OFF]

(4)
$\frac{l_1}{L_1} + \frac{l_2}{L_2} \leq 1 \rightarrow l_2 \leq \left(1 - \frac{l_1}{L_1}\right) L_2$

$l_1 = .5E6$

$l_2 = .25E6$

$L_1 = 1E6\left(\frac{30.7\text{ kN}}{10\text{ kN}}\right)^{3.33} = 42E6$

$L_2 = 1E6\left(\frac{30.7\text{ kN}}{25\text{ kN}}\right)^{3.33} = 2.0E6$

$l_2 \leq 1.98E6$ → NEW LOAD O.K.

$L_1 = 1E6\left(\frac{31.9}{10}\right)^{3.33} = 48E6$

$L_2 = 1E6\left(\frac{31.9}{25}\right)^{3.33} = 2.3E6$

$l_2 \leq 2.3E6$ → NEW LOAD O.K.