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

*NAME:*___________________________ *10:00 AM*

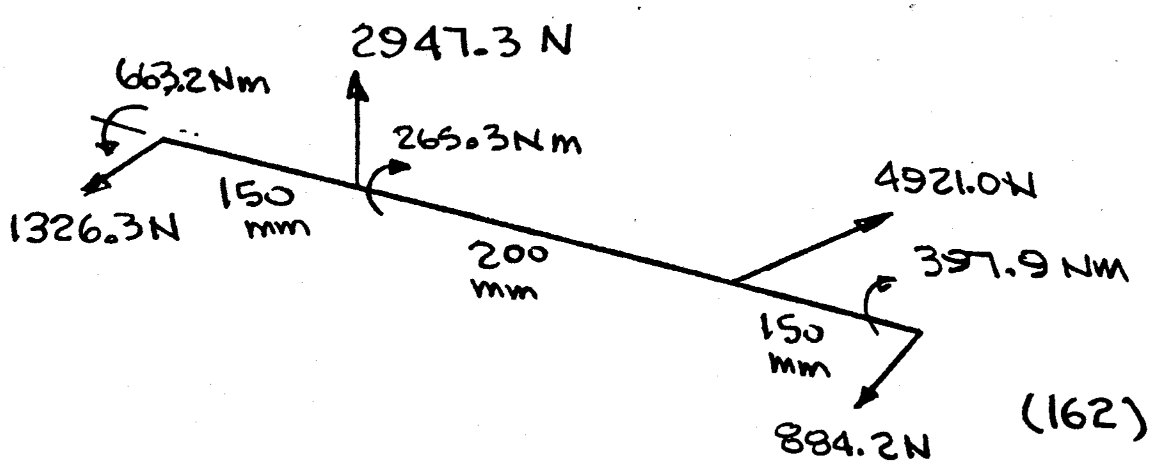
- *Read all problems carefully. Check the board for any additions or corrections.*
- *Show all work, which must be neat and orderly to be graded. That is ,sloppy work will not be graded!*
- *Show no work on this page. Return this page with your solutions.*

(1) A sliding element bearing has an L/d ratio of 1, a diameter of 1.25-inch, and a load of 250 pounds, to a rotational speed of 30- rev/second. The lubricant is SAE 40 oil at an inlet temperature of 120F. The design engineer assumed a viscosity of 10μreyn. Do you agree with that assumption (yes or no) and show the calculations required to support your decision. If you do not agree what should be done to correct the design engineer's error? Using the original data, determine the temperature rise across the bearing, the outlet oil temperature, 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 667.

(2) For the design of problem (1) select a 200 series rolling element bearing which has a reliability of 95% and must last for 25,000 hours. The application is gearing with moderate impact.

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

(4) A bearing has been operated at 2,500,000 cycles at 15-kN. Can this bearing be operated at 25-kN for an additional 250,000 cycles. The bearing is an 02 series with a bore diameter of 80-mm.



EXAM #2 – BEARINGS
TEST CODE 162

① $l = 1.25\text{ in}$
$d = 1.25\text{ in}$
$\frac{l}{d} = 1$
$W = 250\text{ lb}$

$\rightarrow P = \frac{250\text{ lb}}{1.25\text{ in}(1.25\text{ in})} = 160\text{ psi}$

$\frac{r}{c} = 667$
$N = 30\text{ rev/sec}$
SAE 40
$T_i = 120°F$
$T_{AVG,ASSUMED} = 122°F$ $(10\ \mu\text{ reyn})$

ASSUMED TEMPERATURE RISE
$\Delta T_{ASSUMED} = 2(T_{AVG,ASSUMED} - T_i) = 4°F$
$T_{OUT,ASSUMED} = T_i + \Delta T_{ASSUMED} = 124°F$

FIRST CALCULATE THE SOMMERFIELD NUMBER AT THE ASSUMED T_{AVG}

$$S = \left(\frac{r}{c}\right)^2\left(\frac{\mu N}{P}\right) = (667)^2\left(\frac{10\times10^{-6}\text{ reyn}\left(30\frac{\text{rev}}{\text{sec}}\right)}{160\text{ psi}}\right) = 0.83$$

NOW CALCULATE THE TEMP RISE TO SEE IF IT MATCHES

$$\Delta T_F = \frac{0.103P}{1-.5\frac{Q_s}{Q}}\;\frac{\frac{r}{c}f}{\frac{Q}{rcNl}} = \frac{0.103(160)}{1-.5(.23)}\;\frac{15}{3.5} = 80°F$$

ORIGINAL GUESS WAY TOO LOW. SUGGEST MAYBE GUESS $\Delta T = 40°F$, HAVE TO RE-ITERATE UNTIL THE DIFFERENCE IN ASSUMED VS CALCULATED ΔT IS NEAR 5%

USING THE ORIGINAL DATA/ASSUMPTION

ΔT IS AS CALCLUATED ABOVE AT $80°F$

$T_{out} = T_i + \Delta T = 200°F$

① CONT'D

FIND COEFFICENT OF FRICTION (USING ORIGINAL SOMMERFIELD #)

$$\frac{r}{c}f = 15 \rightarrow f = \frac{15}{667} = 0.0225$$

FIND ECCENTRICITY

$$\varepsilon = 0.22 \rightarrow e = \varepsilon c = 0.22\left(\frac{0.625\,in}{667}\right) = 0.0002\,in$$

FIND TOTAL AND SIDE FLOWS

$$\frac{Q}{rcNl} = 3.5 \rightarrow Q = 3.5\cdot\left(.625\,in\right)\left(\frac{.625\,in}{667}\right)\left(30\,\frac{rev}{sec}\right)\left(1.25\,in\right)$$
$$= 0.077\,in^3/sec$$

$$\frac{Q_s}{Q} = 0.23 \rightarrow Q_s = 0.23\left(.077\,in^3/sec\right) = 0.0177\,in^3/sec$$

FIND MAXIMUM OIL PRESSURE

$$\frac{W}{ld} \approx \text{NOMINAL PRESSURE} = P = 160\,psi$$

$$\frac{P}{P_{max}} = 0.54 \rightarrow P_{max} = \frac{160\,psi}{0.54} = 296\,psig$$

FIND POWER LOST IN BEARING

$$T = fWr \quad \& \quad H_p = \frac{TN}{1050}$$

$$H_p = \frac{fWrN}{1050} = \frac{0.0225(250)0.625(30)}{1050} = 0.100\,hp.$$

(2) 200 SERIES

RELIABILITY = 95% → $K_R = 0.62$

$25{,}000\ \text{hr} \times 30\ \text{rev/sec} \times 60\ \frac{\text{sec}}{\text{min}} \times 60\ \frac{\text{min}}{\text{hr}} = 2.7E9$ CYCLES

MODERATE IMPACT → $K_a = 1.75$

$$C_{REQ} = K_a F_e \left(\frac{L}{K_R L_R}\right)^{0.3} = 1.75(1.112\text{ kN})\left(\frac{2.7E9}{.62(90E6)}\right)^{0.3} = 6.23\text{ kN}$$

MINIMUM 35mm BORE → 207 ANGULAR CONTACT OR RADIAL BALL
SHAFT DIA IS 1.25 in = 31.75 mm BUILD UP SHAFT!

(3) THERE IS NO DOWNWARD FORCE IN THE PLANE OF THE PAPER TO COUNTERACT THE 2947.3N UPWARDS FORCE, THUS THE BODY IS NOT IN EQUILLIBRIUM (NOT CORRECT). ALSO, 1326.3 + 884.2 < 4921.0! FOR THE SUM OF FORCES IN HORIZONTAL.

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

$l_1 = 2.5E6$ @ 15 kN = 3372 lb

$l_2 = .25E6$ @ 25 kN = 5620 lb

DEEP GROOVE, $C = 70.2$ kN:

$$L_1 = 1E6\left(\frac{70.2}{15}\right)^{3.33} = 170E6$$

$$L_2 = 1E6\left(\frac{70.2}{25}\right)^{3.33} = 31E6$$

$l_2 = 30.5E6$, THEREFORE O.K. TO OPERATE

ANGULAR CONTACT, $C = 80.6$ kN:

$$L_1 = 1E6\left(\frac{80.6}{15}\right)^{3.33} = 270E6$$

$$L_2 = 1E6\left(\frac{80.6}{25}\right)^{3.33} = 49E6$$

$l_2 = 48.5E6$, THEREFORE O.K. TO OPERATE