EML 3005: Mechanical Design
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Homework 1: Journal Bearing Design Project

The due date for this assignment is Mon Jan 24

The gear pump shown in Fig. 1 supplies pressurized oil to an automobile engine, for lubricating the crank shaft journal bearings, valve train, etc. The pump drive shaft is driven by an external gear, and the two gear shafts that form the pump are supported by two journal bearings each. The pump shaft speed varies, depending on the engine or crankshaft speed. We will assume that pump speed is same as the crank shaft speed.

Design the journal bearings that support the two gear shafts, given that **the max allowable nominal shaft diameter is 0.75 inch** and **bearing L/D ratio is 1.0**. Design only **one bearing** for the **heaviest** loaded support and use the same bearing for all four locations. Bearing design involves determining the appropriate operating radial clearance (c) range.

Present the following design information in a table:

1. Bearing clearance, with appropriate tolerances, at room temperature, and operating temperatures (cases 1-4)
2. Shaft outer and inner diameters with tolerances
3. Bearing inner diameter with tolerances
4. Max oil temp rise for cases 1 through 4
5. Minimum min film thickness (h_o) for cases 1 through 4
6. Required bearing oil supply, and location of oil supply hole, for case 1.

Present the following plots for **Case 1** only.

Min film thickness (h_o), Oil temp rise (ΔT) and Oil flow (Q) Vs. bearing radial clearance. Show the **operating bearing clearance** range on the plot clearly.

OPERATING CONDITIONS

Case 1: Steady freeway speeds with engine at 3000 rpm. Oil temp is 180 F. Ambient temp is 85 F (normal day).

Case 2: Engine is idling at 800 rpm, normal day, with oil temp at 180 F.

Case 3: Hot day (ambient temp is 115 F), vehicle going uphill in low gear with AC on. Engine rpm is 2500 and oil temp is 220 F.

Case 4: Hot day, car has been running at freeway speeds and is suddenly pulled over to a rest area and the engine left idling. Due to heat soak from engine, oil temp is 240 F.

DESIGN INFORMATION

* Minimum allowable min film thickness (ho) is 80 μ-inch (0.00008 inch).
* The max allowable oil temp rise (ΔT) is **50 F**.
* Oil used is **10W30** multiviscosity oil
* Shaft material is 4340 steel with a coefficient of linear expansion of 6.0E-06 in(in- F), and a youngs modulus of 29E06 psi. Bearing housing material is Aluminium with a coefficient of linear expansion of 12.0E-06 in/(in-F).
* Manufacturing precision: Shaft O.D can be held to within +/- 0.0003 inch on the diameter, and the bearing inner dia to within +/- 0.0005 inch.
* Min allowable operating clearance under any circumstance is 0.0002 inch. Shaft should not seize at -40 F (winter weather).
* Radial load from the pressure elements, acting on the shaft vertically down, is given by
  Radial load = Gear O.D (1.0 in) * Gear facewidth (1.0 in) * Oil pressure (psig)
  Oil pressure is 30 psi at idle speed (800 rpm) and 70 psi for 2500 rpm and above.

* Shaft load from the external drive gear is accounted for by assuming that the pump requires 0.25 H.P at idle speed and 1.5 H.P for 2500 rpm and above..
* Max allowable misalignment for the gear elements is 0.0005 in/in. This is satisfied by checking for shaft deflection at the gear center, using information in appendix (pp 735-742). This essentially determines shaft inner dia (d).

Bearing Design Curve Fits

The following curve fits are valid for Sommerfeld numbers between 0.004 and 1.0 for L/D = 1.0

$$\mathbf{0.004 < S < 1.0}$$

$$\frac{h_o}{c} = 0.0247 + 4.2606\ (S) - 10.2144\ (S^2) + 11.4556\ (S^3) - 4.664\ (S^4)$$

$$(\frac{r}{c})f = 0.7316 + 18.9931\ (S) + 0.1877\ (S^2)$$

$$\frac{Q}{rcNL} = 4.8281 - 4.6055\ (S) + 5.9194\ (S^2) - 2.7516\ (S^3)$$

$$\frac{Q_s}{Q} = 0.9614 - 2.6056\ (S) + 3.4272\ (S^2) - 1.6012\ (S^3)$$

$$\mu = 0.7323\ T^{-2.4735}\ ,\quad T\ in\ F$$

Design Report

Present a neat report presenting all the relevant information in a easily understandable format. Assume that you are writing a bearing design report for your employer. Include hand calculations towards the end.

Report is worth **200 points**. Neatness and presentation is worth **50 points**.