Problem of Practices
on
Mechanical Engineering Design
Chapter-14 Lubrication & Journal Bearings

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1. Explain briefly the variation in coefficient of friction with fluid film thickness in journal bearing.
2. A shaft of 20 cm diameter has a speed of 2500 RPM and runs in a bearing which has a length of 1.2 times the diameter. The bearing pressure is 7 kgf/cm^2 and the coefficient of friction at the bearing surface is 0.006. Calculate the horse power lost in friction. The oil flow through the bearing controls the temperature of the bearing. If the difference between the outlet temperature and that at inlet is 20°C, obtain the quantity of oil required if the specific heat is 0.45 and specific gravity is 0.88. Determine the pipe size for (i) oil inlet if the maximum velocity of flow is 1.25 m/sec and (ii) oil drain, the drain to run half full with a maximum oil velocity of 15 m/sec.
3. A 100 mm dia shaft Operating al 2000 rev/min is supported by means of a 150 mm long full journal bearing which is subjected to a radial load of 43 kN. Assume $(\mu N/P) = 30 \times 10^{-6}$. Determine
   (i) the coefficient of friction using McKee equation which is given by

$$f = 0.326\left(\frac{\mu N}{P}\right)\frac{D}{C} + K \text{ , take } D/C \text{ 1000, } K = 0.002.$$

(ii) bearing pressure in MN/m^2.

(iii) heat generated.

4. A 150 mm diameter shaft supporting a load of 10 kN has a speed of 1500 rpm. The shaft runs in a bearing whose length is 1.5 times the shaft diameter. If the diametric clearance of the bearing is 0.15 mm and the absolute viscosity of the oil at the operating temperature is 11 centi-poise, find the lower wasted in friction.

5. An antrifiction bearing used in a gear box has a specification 6108. What do the numbers 6, 1 and 08 signify?

6. Which one of the three bearings listed below will you choose to take a heavy axial load on the bearing (i) self aligning ball bearing (ii) deep groove ball bearing (iii) Thrust bearing.
Give reasons for your selection.

7. A full journal bearing operating under a steady load has the following specifications:
Journal diameter: 60 mm, Bearing length: 60 mm, Radial load on bearing: 2.8 kN, Journal speed: 1020 rpm, Radial clearance: 0.05 mm, Viscosity of oil: 80×10^{-9} N-s/mm^2, Density of oil: 860 kg/m^3, Specific heat of oil: 1.76 kJ/kg-°C
Using Raymonds & Boyd table given at the end of the problem, determine

(i) Sommerfeld Number,

(ii) Power loss in friction,

(iii) Temperature rise if heat generated is entirely carried by oil,

(iv) Minimum film thickness, and its location.

Table - Giving Raymonds & Boyd data for journal bearing for $l/d = 1$

Attitude ε	h_0/c	S	φ	$(r/c)f$	Q/rcn_sl	Q_S/Q	P/P_{max}
0	1.0	00	85	∞	π	0	–
0.1	0.9	1.33	79.5	26.4	3.37	0.150	0.540
0.2	0.8	0.630	74.02	12.8	3.59	0.280	0.529
0.4	0.6	0.264	63.10	5.79	3.99	0.497	0.484
0.6	0.4	0.121	50.58	3.22	4.33	0.680	0.415

8. A full journal bearing has a journal diameter d of 25 mm, with a unilateral tolerance of – 0.038 mm. The bushing bore has a diameter b of 25.038 mm and a unilateral tolerance of 0.075 mm. The l/d ratio is unity. The load is 1.1 kN and the journal runs at 18.33 rps. The average viscosity is 55.2 mPa-s. Minimum film thickness variable is 0.58 and coefficient of friction variable is 4.0. Find

(i) Sommerfeld number,

(ii) minimum film thickness,

(iii) frictional torque.

9. A 360° hydrodynamic bearing has a journal diameter of 60 mm and length 60 mm. It is running at a speed of 1200 rpm. The radial clearance is 0.04 mm and minimum oil thickness is 0.008 mm. Sommerfeld number is 0.0446. Find the viscosity of the oil suitable for the bearing.

10. Design a journal bearing for a centrifugal pump from the following data.
Load on Journal = 15000 N
Speed of the Journal = 900 rpm

Type of oil = SAE 10
Operating Temperature = 55°C
Ambient temperature of oil = 15.5°C
Maximum bearing pressure for pump = 1.5 N/mm^2.
Calculate also the mass of lubricating oil required for artificial cooling if rise of temperature of oil be limited to 15°C. Heat dissipation co-efficient is 1232 W/m^2/°C.

11. A full journal bearing of 50 mm diameter and 100 mm length has a bearing pressure of 1.4 N/mm^2. The speed of the journal is 900 rpm and the ratio of journal diameter to the diametral clearance is 1000. The lubricating oil used has absolute viscosity at operating temperature of 75° is 0.011 kg/m-s. The room temperature is 35°. Determine the amount of artificial cooling required and the mass of lubricating oil required if the difference between the outlet and inlet temperature of the oil is 10°. Take specific heat of oil is 1850 J/kg/°C.

12. A tentative design of a Journal bearing result in a diameter of 75 mm and a length of 125 mm for supporting a load of 20 kN. The shaft runs at 1000 r.p.m. The bearing surface temperature is not to exceed 75° C in a room temperature of 35° C. The oil used has an absolute viscosity of 0.01 kg/m-s at the operating temperature 115° C. Determine the amount of artificial cooling required in watts. Assume d/c = 1000.

13. A turbine shaft running at 1800 r.p.m has a diameter of 300 mm. The load on the bearing due to shaft is 180 kN. Determine the length of the bearing if the allowable bearing pressure is 1.6 N/mm^2. Also find the amount of heat removed by the lubricant per minute, if the bearing temperature is 60° C and viscosity of the oil is 0.02 kg/m-s and the bearing clearance is 0.25 mm.

14. Design a journal bearing for a centrifugal pump running at 1440 rpm. The diameter of the journal is 100 and load on each bearing is 20 kN. The factor ZN/p may be taken as 28 for centrifugal pump bearings. The bearing is running at 75°C, temperature and the atmosphere temperature is 30°C. The energy dissipation coefficient is 875 W/m^2/°C. Take diametral clearance as 0.1 mm.

15. A full journal bearing of 50 mm diameter and 100 mm long has a bearing pressure of 1.4 N/mm^2. The speed of the journal is 900 r.p.m. and the ratio of journal diameter to the diametral clearance is 1000. The bearing is lubricated with oil whose absolute viscosity at the operating temperature of 75°C may be taken as 0.011 kg/m-s. The room temperature is 35°C. Find: 1. The amount of artificial cooling required, and 2. The mass of the lubricating oil required, if the difference between the outlet and inlet temperature of the oil is 10°C. Take specific heat of the oil as 1850 J / kg / °C.