B.E. MECH. ENGG. 4TH YEAR 1ST SEMESTER EXAM 2024

Design of Machine Elements IV

Time: Three hours Full Marks: 100

Use separate answer-scripts for Part A and Part B.

All parts of the same question must be answered at a place. Missing data may be assumed.

:Part A:

Question No 1 is compulsory and answer any **TWO** questions from the rest.

1 a) Explain why ball bearing is preferred in low speed applications.

b) Define BCN. How is it related to Sommerfeld number?

c) State the observations of Tower experiment.

d) State the assumptions of Petroff equation.

e) State the shaft diameter and load range for the bearing 6409V. 10

2 a) State the necessary conditions for pressure development in a hydrodynamic bearing. Explain how these get satisfied in a journal bearing.

b) State the Reynolds equation and explain the significance of different terms in it.

c) Sketch the schematic of a typical hydrostatic bearing with all essential components. Explain why a hydrostatic thrust bearing with constant flow rate is self-compensating in nature.

d) State full-Sommerfeld boundary conditions. Explain the difference between long bearing theory and short bearing theory. 20

3 a) Define static load carrying capacity of rolling element bearings. How does it depend on bearing parameters?

b) The radial load on a ball bearing is 2500 N for first five revolutions and reduces to 1500 N for next ten revolutions. The load variation then repeats itself. Expected life is 20 million revolutions. Determine the dynamic load capacity.

c) Explain mounting and lubrication of rolling contact bearings. 20

4 A full journal bearing is to be used for a shaft with diameter 90 mm, rotating at 1200 rpm and supporting a radial load of 30 kN. In the application area, ambient temperature is 30 deg C

and there is no space restriction and no provision for artificial cooling arrangement. Design the appropriate bearing using the available data given in Tables 1-3. 20

Table 1: Raimondi-Boyd Performance Characteristics for full journal bearings

Length/ Dia	Eccentricity ratio	Sommerfeld No	Friction variable	Attitude angle (deg)	Flow variable
0.5	0.1	4.30	-	81	3.43
	0.2	2.01	40.9	75	3.72
	0.3	1.235	25.7	68	4.00
	0.4	0.785	17.11	62	4.29
	0.5	0.497	11.95	55	4.57
	0.6	0.320	8.08	48	4.85
	0.7	0.185	5.48	41	5.13
	0.8	0.092	3.25	33	5.41
	0.9	0.032	1.59	23	5.69
1	0.1	1.35	-	79	3.37
	0.2	0.632	12.9	74	3.59
	0.3	0.382	8.04	68	3.79
	0.4	0.261	5.80	62	3.99
	0.5	0.179	4.31	56	4.16
	0.6	0.120	3.21	50	4.33
	0.7	0.0765	2.36	43	4.48
	0.8	0.0448	1.71	36	4.62
	0.9	0.0191	1.06	25	4.76
∞	0.1	0.247	-	69	3.03
	0.2	0.123	2.57	67	2.83
	0.3	0.0823	1.90	64	2.52
	0.4	0.0628	1.53	62	2.26
	0.5	0.0483	1.32	58	1.91
	0.6	0.0389	1.20	54	1.56
	0.7	0.0297	1.10	49	1.16
	0.8	0.0211	0.962	42	0.76
	0.9	0.00114	0.721	32	0.41

Table 2: Available Bearing Materials

Bearing Materials	Maximum Unit Load in kN/m^2	Recommended Radial clearance ratio
Lead base babbit	4200-5600	0.0004
Tin base babbit	5600-7000	0.0005
Cadmium base metal	8400-10500	0.0008
Copper-lead (55:45)	14000-21000	0.0010
Copper-lead-tin (72:25:3)	21000-28000	0.0010
Silver (lead-indium overlay)	>35000	0.0010
Bronzes	70000	0.0011

Table 3: Oil viscosity (cP) – temperature variation [linear] data

Oil Grade	20 deg C	100 deg C	
A	40	15	mass density: 880 kg/m^3; specific heat: 1.88 J/g-K
B	50	16	
C	60	18	

:Part B:

Question No 5 is compulsory and answer any **TWO** questions from the rest.

5 Write down short notes on **any two**: 5x2 =10

a) Significance of optimization in design
b) Golden Section Method of Optimization
c) Particle Swarm Optimization
d) Special aspects in design of high speed rotor.

6 a) Explain principles in optimization by Region Elimination methods.
b) Explain Bi-Section method or interval halving method for optimization.
c) Show One iteration for Cauchy's Steepest Descent method for the following objective function f(x) $=x_1^2 + x_2^2 + 2x_1 x_2 + x_2^2 x_1 + 7$ with a starting solution [1,1] 4+6+10

7 a) Explain Ant Colony Method of optimization.
b) Explain the role of Crossing Over in Genetic Algorithm.
c) What is meant by Pareto's Optimal front in Multi-Objective optimization? 10+5+5

8 a) Derive the expression for stresses in a hollow rotor assuming variation of stress across the thickness for a high speed rotor.
b) Show the variation of stresses across the thickness when yielding occurs.
c) What is meant by limit design factor?

or

c) Determine the critical speed for which shrink fit completely loosens up for a given initial interference of δ. 10+5+5