Ref. No.: Ex/ME(M2)/PC/B/T/411/2024(S)

B.E. MECH. ENGG. 4TH YR 1ST SEM SUPPLEMENTARY 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 a question must be answered at a place. Missing data may be assumed.

Part A

In Part A, **Question No 1 is compulsory** and answer any **TWO** questions from the rest.

1 a) Describe Tower experiment. State the observations.

b) Draw and explain Stribeck diagram. 10

2 a) Explain the mechanism for pressure development in a hydrodynamic bearing.

b) Explain the Full-Sommerfeld boundary conditions for hydrodynamic journal bearing analysis. State its limitation. How can it be overcome?

c) Sketch the schematic of a typical hydrostatic bearing with all essential components.

d) Explain why a hydrostatic thrust bearing with constant flow rate is self-compensating in nature. 20

3 a) Explain dynamic load carrying capacity of rolling element bearings. State its relation to bearing load and bearing life.

b) Dynamic load capacity, 90% rated life and rated speed for a taper roller bearing are 20 kN, 7500 hrs and 300 rpm respectively. Find the equivalent radial load that the bearing can take.

c) Explain different methods of lubrication of rolling contact bearings. 20

4 A full journal bearing is to be used for a shaft with diameter 70 mm, rotating at 900 rpm and supporting a radial load of 30 kN. In the application area, ambient temperature is 20 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

[Turn over

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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

In Part B, **Question No 5 is compulsory** and answer any **TWO** questions from the rest.

5 Write down short notes on **any two**:
i) Significance of optimization in design ii) N.L.P of an optimum design
iii) Bi-Section method for optimization iv) Considerations for design of high speed rotor.
v) Multi-objective optimization

5x2 =10

6 a) Classify optimization algorithms
b) Explain Cauchy's Steepest Descent method for optimization
c) Show two iterations for Golden section or interval halving method for the following objective function: $f(x) = x^2 - 4x + 5$ within the interval (0,5).

4+6+10

7 a) Explain Genetic Algorithm or Particle Swarm optimization.
b) Explain penalty function method for constrained optimization.
c) What is meant by non-dominated set of solutions? 10+5+5

8 a) Derive the expression for stresses in a solid 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.
d) How does error in stress evaluated using thin shell formulation vary with thickness and radius? 10+5+5