BACHELOR OF ENGINEERING (MECHANICAL ENGINEERING)

FOURTH YEAR FIRST SEMESTER EXAM 2024

Subject: MACHINE DESIGN IV

Marks: 100 Time: 3 hrs

(Answer **Q. no. 1** and any **five** from the rest)

Q. no. 1: Write correct answer/s from the options given:

1. Autofrettage is a process of _______ stressing the cylinder.
   a) Post b) Pre c) Maximum d) Over

2. A unfired pressure vessel de3fined as a vessel which stores gas/liquid/steam at
   a) Lower than atmosphere pressure b) higher than atmosphere pressure c) equal to atmosphere d) LPG

3. While designing pressure vessels according to 'Code for unfired vessel IS-2825', the design pressure is taken as
   a) 1.5 times maximum working pressure
   b) 2.0 times maximum working pressure
   c) 1.3 times maximum working pressure
   d) 1.05 times maximum working pressure

4. In thick cylinders, the tangential stress across the thickness of cylinder
   a) Remains uniform throughout
   b) Varies from internal pressure at the inner surface to zero at the outer surface
   c) Varies from maximum value at the inner surface to minimum value at the outer surface
   d) Varies from maximum value at the outer surface to minimum value at the inner surface

5. The thickness of high-pressure oil and gas pipes is determined by
   a) Lame's equation
   b) Clavarino's equation
   c) Birnie's equation
   d) Barlow's equation

6. In the assumptions of Petroff's law
   a) Radial load is almost zero
   b) Viscosity of the lubricant is very high
   c) Journal speed is very high
   d) Journal speed is very low

7. For radial load "W", bearing radius "R" and length "L", unit bearing pressure "P" is
   a) WR/L b) 2W/RL c) W/2RL d) WL/R

8. For derivation of Reynold's equation, some of the following assumptions are

a) The shaft is rigid
b) The bearing is rigid
c) The flow in the direction perpendicular to the motion is neglected
d) Inertia forces due to motion of the fluid is considered

9. A journal bearing has shaft diameter of 40 mm and a length of 40 mm. The shaft is rotating at 20 rad/s and the viscosity of the lubricant is 20 mPa.s. The clearance is 0.020 mm. Loss of torque due to fluid action is
   a) 0.040 Nm b) 0.25 Nm c) 0.08 Nm d) 0.025 Nm

10. Hydrodynamic lubrication depends on
    a) Lubricant's pressure
    b) Clearance between journal and bearing
    c) Journal speed only
    d) Adequate lubricant supply in the clearance

11. Elasto-hydrodynamic lubrication exhibits in
    a) Cam-follower mating surfaces
    b) Mating gears
    c) Rolling bearings
    d) None of the above

12. Units of kinematic viscosity is
    a) Poise b) Centi-poise c) Stoke d) Pa.s

13. If the length to diameter ratio (l/d) increases
    a) Side flow increases
    b) Heat dissipation increases
    c) Resulting film pressure increases
    d) Susceptible to metal to metal contact at edges

14. Unit bearing pressure for starting condition should not exceed
    a) 3 N/mm^2 b) 1.5 N/mm^2 c) 4 N/mm^2 d) 2 N/mm^2

15. The ratio of longitudinal stress to tangential stress in case of cylindrical shell is
    a) 1.5 b) 2.0 c) 1.0 d) 0.5

15x2=30

Q. no. 2:

Derive the general expression of stresses in a thick cylinder subjected to both internal and external pressures. Show the radial and circumferential stress distributions in the cylinder for internal pressure only.

10+4=14

Q. no. 3:

A hydraulic cylinder with an internal diameter 250 mm is subjected to an internal pressure of 10 MPa. Determine the wall thickness based on a) Maximum principal stress theory, b) Maximum shear stress theory of failure. Compare the results of wall thickness calculated based on thin cylinder assumption. Assume the yield stress of the cylinder material to be 60 MPa.

Q. no. 4:

Derive the Reynold's equation. Also state all assumptions for deriving the Reynold's equation.

10+4=14

Q. no. 5:

Following data are given for a hydrostatic thrust bearing:

Thrust load = 550 kN; Shaft speed = 720 rpm; Shaft diameter = 500 mm; Recess diameter = 300 mm; Film thickness = 0.15 mm; Viscosity of lubricant = 160 SUS; Specific gravity = 0.86;

Calculate: (a) Supply pressure

(b) Flow requirement

(c) Power loss

14

Q. no. 6:

Following data is given for a 360^0 hydrodynamic bearing:

Radial load = 3.2 kN

Journal speed = 1490 rpm

Journal diameter = 50 mm

Bearing length = 50 mm

Radial clearance = 0.05 mm

Viscosity of the lubricant = 25 cP

Assuming that the total heat generated in the bearing is carried away by the total oil flow in the bearing, calculate:

a) Coefficient of friction

b) Power loss on friction

c) Minimum oil film thickness

d) Flow requirement

e) Temperature rise.

14

Q. no. 7:

a) What is McKees investigation?

b) Derive the petroff's equation. 6+8=14

Q. no. 8:

a) Explain different types of lubrication in short.

b) What is stable lubrication?

c) What is Sommerfeld Number? How it is related to bearing modulus?

4+4+6=14

Dimensionless performance parameters for full journal bearing with side flow

$\left(\frac{l}{d}\right)$	ε	$\left(\frac{h_o}{c}\right)$	S	ϕ	$\left(\frac{r}{c}\right)f$	$\left(\frac{Q}{rcn_s l}\right)$	$\left(\frac{Q_s}{Q}\right)$	$\left(\frac{p}{p_{max}}\right)$
∞	0	1.0	∞	(70.92)	∞	π	0	–
	0.1	0.9	0.240	69.10	4.80	3.03	0	0.826
	0.2	0.8	0.123	67.26	2.57	2.83	0	0.814
	0.4	0.6	0.0626	61.94	1.52	2.26	0	0.764
	0.6	0.4	0.0389	54.31	1.20	1.56	0	0.667
	0.8	0.2	0.021	42.22	0.961	0.760	0	0.495
	0.9	0.1	0.0115	31.62	0.756	0.411	0	0.358
	0.97	0.03	–	–	–	–	0	–
	1.0	0	0	0	0	0	0	0
1	0	1.0	∞	(85)	∞	π	0	–
	0.1	0.9	1.33	79.5	26.4	3.37	0.150	0.540
	0.2	0.8	0.631	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
	0.8	0.2	0.0446	36.24	1.70	4.62	0.842	0.313
	0.9	0.1	0.0188	26.45	1.05	4.74	0.919	0.247
	0.97	0.03	0.00474	15.47	0.514	4.82	0.973	0.152
	1.0	0	0	0	0	0	1.0	0
$\left(\frac{1}{2}\right)$	0	1.0	∞	(88.5)	∞	π	0	–
	0.1	0.9	4.31	81.62	85.6	3.43	0.173	0.523
	0.2	0.8	2.03	74.94	40.9	3.72	0.318	0.506
	0.4	0.6	0.779	61.45	17.0	4.29	0.552	0.441
	0.6	0.4	0.319	48.14	8.10	4.85	0.730	0.365
	0.8	0.2	0.0923	33.31	3.26	5.41	0.874	0.267
	0.9	0.1	0.0313	23.66	1.60	5.69	0.939	0.206
	0.97	0.03	0.00609	13.75	0.610	5.88	0.980	0.126
	1.0	0	0	0	0	–	1.0	0
$\left(\frac{1}{4}\right)$	0	1.0	∞	(89.5)	∞	π	0	–
	0.1	0.9	16.2	82.31	322.0	3.45	0.180	0.515
	0.2	0.8	7.57	75.18	153.0	3.76	0.330	0.489
	0.4	0.6	2.83	60.86	61.1	4.37	0.567	0.415
	0.6	0.4	1.07	46.72	26.7	4.99	0.746	0.334
	0.8	0.2	0.261	31.04	8.8	5.60	0.884	0.240
	0.9	0.1	0.0736	21.85	3.50	5.91	0.945	0.180
	0.97	0.03	0.0101	12.22	0.922	6.12	0.984	0.108
	1.0	0	0	0	0	–	1.0	0