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| Seat No. | |
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T.E. (Mechanical) (Semester – II) Examination, 2014
MACHINE DESIGN – II
(2008 Course)

Time : 4 Hours

Max. Marks : 100

- Instructions :**
- 1) Solve Q. 1 or Q. 2, Q. 3 or Q. 4, Q. 5 or Q. 6 from Section – I and Q. 7 or Q. 8, Q. 9 or Q. 10, Q. 11 or Q. 12 from Section – II.
 - 2) Answers to the two Sections should be written in **separate** books.
 - 3) **Neat** diagrams must be drawn **wherever** necessary.
 - 4) Figures to the **right** indicate **full** marks.
 - 5) **Use** of electronic pocket calculator is **allowed**.
 - 6) Assume **suitable** data, **if necessary**.

SECTION – I

1. a) Compare ball bearings with roller bearings. State the applications of rolling contact bearings. **4**
- b) A shaft with centrally mounted helical pinion is supported by deep groove ball bearings at both ends. The centre distance between the bearings is 200 mm. the shaft transmits 5 kW power at 3000 r.p.m. The pitch circle diameter of the pinion is 80 mm. The normal pressure angle and helix angle are 20° and 25° respectively. The expected life of the bearings is 10000 hours with a reliability of 95%. Calculate the dynamic load carrying capacity of the bearing which takes up the axial thrust so that it can be selected from the manufacturer's catalogue based on the reliability of 90%. **12**

OR

2. a) An equivalent radial load on a bearing varies continuously from 0 to 20 kN in a sinusoidal manner. Determine the dynamic load rating at 90% reliability, if the bearing is to have a life of 20 million revolutions at a reliability of 99%. Assume shaft speed as 1000 r.p.m.

Use life reliability relationship

$$\frac{L}{L_{10}} = \left[9.491 \log_e \left(\frac{1}{R} \right) \right]^{\frac{1}{1.17}}$$

12

- b) Explain the designation of rolling contact bearing. **4**

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3. a) Compare short and Infinitely long bearings. 4

- b) The following data is given for a 360° hydrodynamic bearing : 14

Journal bearing = 50 mm

Bearing length = 50 mm

Radial load = 3.2 kN

Journal Speed = 1490 r.p.m.

Radial clearance = 0.05 mm

Viscosity of lubricant = 25 cP

Assuming that the total heat generated in the bearing is carried by the total oil flow in the bearing and Table No. 1 given in Q.4 (b) Calculate :

- I) Minimum film thickness
- II) Coefficient of friction and
- III) Power lost in friction
- IV) Flow requirement in liters/min and
- V) Temperature rise.

OR

4. a) What are the desirable properties of the sliding contact bearing material ? 4

- b) The following data is given for a 360° hydrodynamic bearing : 14

Journal diameter = $50^{-0.080}_{-0.119}$

Bearing diameter = $50^{+0.039}_{+0.000}$

Bearing length = 50 mm

Journal speed = 1500 r.p.m.

Radial load 5 kN



The bearing is machined on a lathe from bronze casting, while the steel journal is hardened and ground. The surface roughness (CLA) values for turning and grinding are 3.2 and 0.8 microns respectively. For thick film hydrodynamic lubrication, the minimum film thickness should be 6 times the sum of surface roughness values for the journal and bearing. Determine the quality and quantity of the lubricant required.

Table 1 : Dimensionless performance parameters for 360° journal bearing for l/d = 1

| $\frac{h_0}{c}$ | s | $\left(\frac{r}{c}\right)f$ | $\frac{Q}{rcn_s l}$ | $\frac{Q_s}{Q}$ |
|-----------------|--------|-----------------------------|---------------------|-----------------|
| 0.9 | 1.33 | 26.4 | 3.37 | 0.150 |
| 0.8 | 0.631 | 12.8 | 3.59 | 0.280 |
| 0.6 | 0.264 | 5.79 | 3.99 | 0.497 |
| 0.4 | 0.121 | 3.22 | 4.33 | 0.680 |
| 0.2 | 0.0446 | 1.70 | 4.62 | 0.842 |
| 0.1 | 0.0188 | 1.05 | 4.74 | 0.919 |

5. a) Explain the significance of fatigue stress concentration factor and notch sensitivity. 4
- b) A cantilever beam of circular cross section is fixed at one end and subjected to completely reversed force of 10 kN at free end. The force is perpendicular to the axis of the beam. The distance between free and fixed ends is 100 mm. the beam is made of steel with ultimate tensile strength of 540 N/mm² and yield strength of 320 N/mm². The construction of cantilever beam is such that there is no stress concentration. The size factor, surface finish factor and reliability factor are 0.85, 0.8 and 0.868. The operating temperature is 50° c for which the temperature factor is 1.010. If the diameter of the beam is 35 mm, determine the life of the beam. 12

OR

6. a) Why modified Goodman diagram is widely accepted ? 2
- b) The work cycle of a mechanical component subjected to completely reversed bending stresses consists of the following three elements : 14
- i) ± 350 N/mm² for 85% of the time,
 - ii) ± 400 N/mm² for 12% of the time, and
 - iii) ± 500 N/mm² for 3% of the time.

The material for the component is 50C4 ($S_{ut} = 660$ N/mm²) and the corrected endurance limit of the component is 280 N/mm². Determine the life of the components. Also determine the life of the components if the material is changed from 50C4 to 20C8 ($S_{ut} = 540$ N/mm²).

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SECTION – II

7. a) Discuss the properties of friction lining material. 4

b) An oil immersed multi plate clutch, consisting of alternate steel and asbestos lining plates, is used to transmit 20 kW power at 3080 r.p.m. The coefficient of friction between the steel and asbestos lining plates is 0.12 and the permissible intensity of pressure is 0.3 N/mm². The radial space restriction limits the outer diameter of the asbestos lining plates to 130 mm. Assuming the suitable operating condition, determine the inner diameter of contacting surfaces, the number of steel and asbestos lining plates and the axial force required to engage the clutch. 12

OR

8. a) What is the significance of the 'pv' value in the design of brakes ? 4

b) A pivoted double block brake has two shoes each of which subtend an angle of 120° at the centre of the brake drum. The diameter of the brake drum is 450 mm. and the width of the friction lining is 75 mm. The coefficient of friction is 0.2 and the maximum intensity of pressure between the lining and the brake drum is 0.5 N/mm². The pivot of each shoe is located in such a manner that the moment of force of friction on shoe about the pivot is zero. Assuming that the same actuating force is applied on both shoes, calculate, the distance of the pivot from the axis of the brake drum, the braking torque capacity of the brake and the pivot reactions. 12

9. a) The following data given for steel gear pair transmitting 5 kW power from an electric motor running at 720 r.p.m. to a machine 14

Number of teeth on pinion = 21

Number of teeth on gear = 40

Face width = 10 m



Ultimate and Yield tensile strength for pinion and gear material = 600 N/mm² and 400 N/mm² respectively.

Tooth system = 20° full depth involute

Taking a service factor of 1.25, load concentration factor 1.6 and a factor of safety of 2, calculate :

- i) Module based on velocity factor $C_v = \frac{6}{6+v}$. Take form factor for pinion as 0.326 and for gear 0.389.
- ii) Select the standard module and calculate the main dimensions of the gear.
- iii) Specify the surface hardness of gear.

Use following data

- Load stress factor = $0.16 \left(\frac{\text{BHN}}{100} \right)^2 \text{ N/mm}^2$
- Standard module in mm : 1, 1.25, 2.0, 2.5, 3.0, 4.0, 5.0, 6.0, 8.0, 10.0

Assume pitch line velocity 5 m/s

- b) State advantages of 20° pressure angle tooth system.

4

OR

10. The following data is given for the pair of helical gears

18

Power transmitted 20 kW

Pinion Speed 1440 rpm

Number of teeth on pinion 35

Number of teeth on gear 70

Normal pressure angle 20°

Helix angle 23°

Face width 40 mm

$$\text{Velocity factor } C_v = \frac{5.6}{5.6 + \sqrt{v}}$$

Ultimate tensile strength for gears 600 MPa

Service factor 1.5

Factor of safety 1.5

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Deformation factor $C = 11400 X_e$

For Grade 6, $e = 8.00 + 6.3\phi$, $\phi = m + 0.25\sqrt{d}$

Estimate :

- The normal module and main dimensions of the gears.
- Beam strength.
- Dynamic load using Buckingham's Equation.
- Surface hardness for the gears and check the wear strength of the gears

$$\text{Use Buckingham's equation as } P_d = \frac{21v[bC \cos^2 \alpha + P_{t\max}]}{21v + \sqrt{bC \cos^2 \alpha + \alpha P_{t\max}}}$$

11. A pair of straight bevel gear mounted on shafts that are intersecting at right angles consists of a 24 teeth pinion meshing with 32 teeth gear. The pinion shaft is connected to an electrical motor developing 12.5 kW rated power at 1440 r.p.m. The starting torque of the motor is 150% of the rated torque. The pressure angle is 20°. Both the gears are made of the steel $S_{ut} = 750$ MPa. The teeth on gears are generated and finished by grinding and lapping processes to meet the requirements of class 3 grade. The factor of safety in preliminary design stages is 2. 16

- In the initial stages of gear design, assume that the velocity factor accounts for the dynamic load and that the pitch line velocity is 7.5 m/s. Estimate the module and determine the main dimensions of the gears.
- Determine the dynamic load using Buckingham's equation and find out the effective load for the above dimensions. Find the available factor of safety in bending.
- Specify the surface hardness for the gears assuming a factor of safety of 2.

Use following data :

$$\text{Lewis form factor} = 0.485 - \frac{2.87}{Z}$$

$$\text{Load stress factor} = 0.16 \left(\frac{\text{BHN}}{100} \right)^2 \text{ N/mm}^2$$

$$\text{Buckingham's equation for dynamic load in tangential direction } P_d = \frac{21v(bC + P_t)}{21v + \sqrt{bC + P_t}}$$

$$\text{Velocity factor } C_v = \frac{5.6}{5.6 + \sqrt{v}}$$

Deformation factor $C = 11400 X_e$

Maximum expected error between meshing teeth (mm)

| Module (mm) | Up to 4 | 5 | 6 | 7 | 8 |
|---------------------|---------|--------|--------|--------|--------|
| Class 3 grade-error | 0.0125 | 0.0125 | 0.0150 | 0.0170 | 0.0190 |

OR



12. a) Obtain an expression for the efficiency of a worm gear drive. **6**
- b) Sketch and describe the arrangement of a work gear box in which the difference of temperature of the lubricant oil more than 100°C. **4**
- c) A worm and worm wheel designated by 2/60/10/6 transmits 5 kW power at 1440 r.p.m. The worm is left handed type and rotates in an anticlockwise direction as viewed from the right side. The coefficient of friction between the worm and worm wheel is 0.05, while the normal pressure angle is 20°. **6**

Determine :

- i) The efficiency of worm gear pair and
- ii) The power lost in friction.