**B.TECH/ME/6TH SEM/MECH 3251/2018**

**DESIGN OF MECHANICAL SYSTEMS - II**

**(MECH 3251)**

**Time Allotted : 3 hrs Full Marks : 70**

***Figures out of the right margin indicate full marks.***

***Candidates are required to answer Group A and***

***any 5 (five) from Group B to E, taking at least one from each group.***

***Candidates are required to give answer in their own words as far as practicable.***

(For all the design constants attached Data Sheet may be referred)

**Group – A**

**(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: **10 × 1 = 10**

 (i) When the axes of two shafts are perpendicular and non-intersecting, use

(a) spur gears (b) bevel gears

(c) worm gears (d) helical gears.

 (ii) The axial component of resultant force on worm wheel is equal to

(a) tangential component on worm (b) radial component on worm

(c) axial component on worm (d) none of the above.

 (iii) The friction material of the clutch should have

(a) high coefficient of friction (b) low coefficient of friction

(c) high surface hardness (d) high endurance limit strength.

 (iv) Compared with spur gears, helical gears

(a) run more smoothly (b) run with noise and vibrations

(c) consume less power (d) run exactly alike.

 (v) For high pressure oil and gas cylinders, the thickness of the cylinder is determined by

(a) Lame’s equation (b) Clavarino’s equation

(c) Barlow’s equation (d) Birnie’s equation.

 (vi) For a band brake, the width of the band for a drum diameter greater than 1 m, should not exceed.

(a) 150 mm (b) 200 mm (c) 250 mm (d) 300 mm.

 (vii) Rolling contact bearings as compared to sliding contact bearings

(a) have lower starting torque

(b) require considerable axial space

(c) generate less noise

(d) are more costly.

 (viii) A bearing number XX10 indicates that the bearing is having

(a) bore diameter of 10 mm (b) bore diameter of 100mm

(c) bore diameter of 50 mm (d) outer diameter of 100mm

 (ix) The balls of rolling contact bearings are made of

(a) case hardened steel (b) plain carbon steel

(c) high carbon chromium steel (d) free cutting steel.

 (x) Sommerfeld number is

(a) similar to bearing characteristic number

(b) similar to Reynold’s number

(c) dimensionless parameter that contains all the design parameters

(d) used to find out dynamic load carrying capacity of the hydrodynamic bearing.

**Group – B**

2. It is required to design a pair of spur gears with 20° full-depth involute teeth consisting of a 20 teeth pinion meshing with a 50 teeth gear. The pinion shaft is connected to a 22.5 KW, 1500 rpm electric motor. The starting torque of the motor can be taken as 150% of the rated torque. The material for the pinion is plain carbon steel Fe410 (Sut = 410 N/mm2), while the gear is made of Grey Cast Iron FG200 (Sut = 200 N/mm2). The factor of safety is 1.5.

 Design the gear

 (i) for strength based on Lewis equation and using velocity factor to account for the dynamic load.

 (ii) check the design for wear strength considering surface hardness of cast iron pinion to be 250 BHN.

 Lewis form factor can be determined from the following expression,

 $Y= π \left(0.154-\frac{0.912}{Number of Teeth}\right)$

**8 + 4 = 12**

3. The following data is given for a pair of parallel helical gears made of steel.

(i) Power transmitted = 20 kW, (ii) Speed of pinion = 720 rpm, (iii) Number of tooth on pinion = 35, Number of teeth on Gear = 70, Centre distance = 285 mm, Normal Module = 5 mm, Normal Pressure angle = 20°, Ultimate tensile strength = 600 N/mm2, Surface hardness = 300 BHN and service factor = 1.25.

Determine (i) Helix angle, (ii) Beam strength, (iii) Wear Strength, (iv) Static Load and (v) Effective load considering velocity factor to account for the effect of dynamic load.

**2 + 3 + 3 + 2 + 2 = 12**

**Group – C**

4. A pair of straight bevel gears consists of a 24-teeth pinion meshing with a 48-teeth gear. The module at the outside diameter is 6 mm, while the face width is 50 mm. The gears are made of cast iron FG 220 (Sut = 220 MPa). The pressure angle is 20°. The teeth are generated and assume the velocity factor accounts for the dynamic load. The pinion rotates at 300 rpm and the service factor is 1.5. Calculate:

(i) The beam strength of the tooth.

(ii) The static load that the gear can transmit with a factor of safety of 2 for bending consideration and

(iii) The rated power that the gear can transmit.

**6 + 4 + 2 = 12**

5. (a) The maximum force exerted by a small press is 500 kN. The working pressure of the fluid is 20 N/mm2. Determine the diameter of the plunger, operating the table. Also suggest the suitable thickness for the cast steel cylinder in which the plunger operates, if the permissible stress for cast steel is 100 MPa.

 (b) Show with a neat sketch the variations in radial and circumferential stresses across the thickness of a thick cylinder under (i) internal pressure (ii) external pressure.

**(2 + 4) + (3 + 3) = 12**

**Group – D**

6. (a) Show that the torque transmitting capacity of a single plate clutch with one pair of contacting surfaces is maximum when (d/D) is equal to 0.577, where d & D has their usual meaning. Assume suitable parameters.

 (b) A multiple disk clutch, steel on bronze, is designed on the basis of uniform pressure condition to transmit 20 kW at 1440 rpm. The coefficient of friction and average pressure was taken as 0.08 and 0.3 MPa respectively. The initial design dimensions are as follows.

Number of friction surfaces = 4

Outer diameter = 230 mm

Inner diameter = 164 mm

Face width = 33 mm

Total number of spring used for clamping force = 6

Stiffness of the spring = 125 N/mm

The clamping force is provided by compressing each spring by 8 mm.

After three years of use, slippage occurs. Find out the cause of the slippage.

**5 + 7 = 12**

7. (a) What is a self-energizing brake? When a brake becomes self-locking?

 (b) A differential band brake shown in Figure 1 has drum diameter of 500 mm. One end of the band is attached to the left of the fulcrum at a distance of 50 mm and the other end is attached to the right of the fulcrum at a distance of 200 mm from the fulcrum. The brake is to sustain a torque of 450 N-m. The coefficient of the friction is 0.2 and the angle of contact is 3.5 radian. The length of the point of application of the load from the fulcrum is 600 mm. determine (i) the braking force if the drum rotates in the clockwise direction (ii) the braking force if the drum rotates in the anticlockwise direction (iii) the condition of self-locking for anticlockwise rotation.

***Figure 1***



***Figure 1***

**(3 + 2) + (2 + 2 + 3) = 12**

**Group – E**

8. A 70 mm machine shaft is to be supported at the ends. It operates continuously for 8 hrs per day and 320 days per year for 8 years. The load and speed cycle for one of the bearings are given below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sl No. | Fraction of Cycle | Radial Load (N) | Thrust Load (N) | Speed (rpm) | Factors |
| X | Y | Service Factor (S) |
| 1 | 0.25 | 3500 | 1000 | 600 | 0.56 | 1.2 | 1.5 |
| 2 | 0.25 | 3000 | 1000 | 800 | 0.56 | 1.2 | 1.5 |
| 3 | 0.5 | 4000 | 2000 | 900 | 0.56 | 1.4 | 1.5 |

Considering load factor as 1.35 along with the service factors as mentioned in the table above calculate load carrying capacity of the bearings and select suitable bearings. Consult with the data sheet given if necessary.

**8 + 4 = 12**

9. Following data is given for a 360° hydrodynamic bearing:

 Bearing Diameter = 50.02 mm

 Journal Diameter = 49.93 mm

 Bearing Length = 50 mm

 Journal Speed = 1440 mm

 Radial Load = 8 kN

 Viscosity of the Lubricant = 12cP

 The bearing is machined on the lathe from bronze casting, while steel journal is hardened and ground. The surface roughness (c.l.a) values for turning and grinding are 0.8 and 0.4 microns respectively. For thick film hydrodynamic lubrication, the minimum film thickness should be five times the sum of surface roughness values for the journal and bearing. Calculate following parameters consulting the Raimondi-Boyd chart mentioned below.

(i) The permissible minimum film thickness.

(ii) The actual film thickness under operating conditions.

(iii) Power lost in friction.

**4 + 4 + 4 = 12**