CBCS SCHEME

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15ME63

Sixth Semester B.E. Degree Examination, Aug./Sept.2020
Heat Transfer

Time: 3 hrs. Max. Marks: 80

Note: **1.** ***Answer any FIVE full questions, choosing ONE full question from each module.***
2. ***Use of Heat and Mass Transfer data handbook is permitted.***

Module-1

1 a. Derive the 3-D heat conduction equation in Cartesian coordinate system for an isotropic material. Also write special forms of 3-D heat conduction equation. **(08 Marks)**

b. A furnace wall is made up of three layers of thickness 250 mm, 100 mm, 150 mm with thermal conductivities of 1.65, K, 9.2 W/m-K respectively. The inside is exposed to gases at 1250°C with convection coefficient of 25 W/m^2-K and outside surface is exposed to air at 25°C with convection coefficient of 12 W/m^2-K, inside surface is maintained at 1100°C. Determine:
(i) The unknown thermal conductivity
(ii) Overall heat transfer coefficient
(iii) All surface temperatures. **(08 Marks)**

OR

2 a. Explain the modes of heat transfer with corresponding governing laws. **(06 Marks)**

b. Explain the three kinds of boundary conditions to solve conduction problems. **(04 Marks)**

c. A wall of steam boiler furnace is made of layers of fire clay of thickness 12.5 cm (K_1 = 0.28 + 0.00023T W/m°C) and red brick of 50 cm (K_2 = 0.7 W/m°C) where T is in °C. The inside surface temperature of fire clay is 1100°C and outside brick wall temperature is 50°C. Calculate the amount of heat loss per unit area of the furnace wall and the temperature at the interface. **(06 Marks)**

Module-2

3 a. What do you mean by critical thickness of insulation? Derive an expression for critical thickness of insulation for cylinder. **(05 Marks)**

b. In a thermal conductivity measuring experiment two identical long rods are used. One rod is made of aluminium (K = 200 W/m-K). The other rod is specimen. One end of both the rods is fixed to a wall at 100°C, while the other end is suspended in air at 25°C. The steady temperature at the same distance along the rods were measured and found to be 75°C on aluminium and 60°C on specimen rod. Find thermal conductivity of the specimen. Assume that the fin is insulated at the tip. **(05 Marks)**

c. Show that the temperature distribution under lumped analysis is given by, $\frac{T-T_\infty}{T_i-T_\infty} = e^{-Bi.Fo}$

where T_i is the initial temperature and T_∞ is the surrounding temperature. **(06 Marks)**

OR

4 a. What is the main purpose of fins? Define fin efficiency and fin effectiveness. **(04 Marks)**

b. What are Heisler charts? Explain their significance in solving transient conduction problems. **(04 Marks)**

c. A 12 mm diameter mild steel sphere at 540°C is exposed to cooling air flow at 27°C and heat transfer coefficient of 114 W/m2-K. Find:
   (i) The time required to cool the sphere from 540°C to 95°C
   (ii) Instantaneous heat transfer rate, two minutes after start of cooling
   (iii) Total heat transferred from the sphere during first two minutes.
   Properties of mild steel are: $\rho = 7850$ kg/m^3, C = 475 J/kg-K and $\alpha = 0.045$ m^2/hr. **(08 Marks)**

Module-3

5 a. Why numerical methods are preferred over analytical methods? List the numerical methods which are used in solving heat conduction problems. **(04 Marks)**

b. The boundary temperatures of a thin plate are as shown in Fig.Q5(b). Determine the temperature at the centre of the plate.

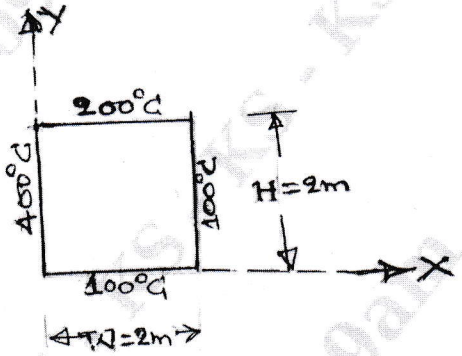

Fig.Q5(b) **(06 Marks)**

c. Explain:
   (i) Kirchhoff's law
   (ii) Plank's law
   (iii) Wien's displacement law **(06 Marks)**

OR

6 a. How is Laplace equation for 2D heat conduction approximated to the finite difference equations? **(08 Marks)**

b. Calculate the net radiant heat exchange per unit area for two large parallel plates at temperature of 427°C and 27°C respectively. Take emissivity of hot plate and cold plates are 0.9 and 0.6 respectively. If a polished aluminium shield is placed between them, find percentage reduction in the heat transfer. Take emissivity of shield as 0.4. **(08 Marks)**

Module-4

7 a. With the help of dimensional analysis obtain the fundamental relation between dimensionless numbers required for
   (i) Forced convection
   (ii) Natural convection. **(10 Marks)**

b. Water at a velocity of 1.5 m/s enters a 2 cm diameter heat exchanger tube at 40°C. The heat exchanger tube wall is maintained at a temperature of 100°C. If the water is heated to a temperature of 80°C in the heat exchanger tube, find the length of the exchanger tube required. **(06 Marks)**

OR

8 a. Define an explain the physical significance of the following dimensionless numbers:
(i) Grashoff number
(ii) Reynolds number **(04 Marks)**

b. For fluid flow over a flat plate, sketch (i) Velocity boundary layer (ii) Thermal boundary layer. Clearly mention salient points on the figure. **(04 Marks)**

c. A tube of 0.036 m OD and 40 cm length is maintained at a uniform temperature of 100°C. It is exposed to air at a uniform temperature of 20°C. Determine the rate of heat transfer from the surface of the tube when (i) the tube is vertical (ii) the tube is horizontal. **(08 Marks)**

Module-5

9 a. What is the importance of NTU effectiveness method? Derive an expression for the effectiveness of a parallel flow heat exchanger. **(08 Marks)**

b. Sketch pool boiling curve for water and explain the various regimes in boiling heat transfer. **(08 Marks)**

OR

10 a. List the assumptions made in Nusselt's theory of laminar film condensation on a plane vertical surface. **(04 Marks)**

b. Saturated steam at 80°C condenses as a film on a vertical plate at a temperature of 70°C. Calculate the average heat transfer coefficient and the rate of steam condensation per hour. Assume that the latent heat of vaporization at 80°C as 2309 kJ/kg. **(06 Marks)**

c. An oil cooler for a large diesel engine is to cool engine oil from 60 to 45°C using sea water at an inlet temperature of 20°C with a temperature rise of 15°C. The design load Q = 140 KW and the mean overall heat transfer coefficient based on the outer surface area of the tubes is 70 $W/m^2°C$. Calculate the heat transfer surface area for single pass counter flow and parallel flow arrangement. **(06 Marks)**

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15ME64

Sixth Semester B.E. Degree Examination, Aug./Sept.2020
Design of Machine Elements – II

Time: 3 hrs. Max. Marks: 80

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of hand book is permitted.

Module-1

1 a. Write the difference between a straight and curved beam. **(06 Marks)**

b. The cross-section of a curved link is a symmetrical trapezium 50mm deep. The inner width and outer width are 50mm and 25mm respectively. Find the maximum stress when the link carries a load of 15 kN which passes through the centre of curvature of link. The internal radius of link as 50mm. **(10 Marks)**

OR

2 A tube with 50mm and 75mm as inner and outer diameter respectively, is reinforced by shrinking a jacket of outer diameter 10mm. The compound tube is to withstand an internal pressure of 35 MPa. The shrinkage allowance is such that the maximum tangential stress in each tube has same magnitude. Calculate shrinkage pressure and the original dimensions of the tube. Assume E = 207 kN/mm^2. **(16 Marks)**

Module-2

3 a. Explain the effect of slip, creep and centrifugal tension in flat belt drive. **(03 Marks)**

b. Specify he details of a V-belt drive for a 10 kW, 1160 rpm induction motor operating a fan at approximately 400 rpm. The centre distance between pulley is to be close to 1m, $\alpha = 34°$. **(13 Marks)**

OR

4 a. One helical spring is nested inside another; the dimensions are as tabulated. Both springs have the same free length and carry a total maximum load of 2500 N.

	Outer spring	Inner spring
No. of active coils	6	10
Wire diameter, mm	12.5	9.00
Mean coil diameter, mm	100	70

Determine : (i) The maximum load carried by each spring.
(ii) The total deflection of each spring
(iii)The maximum stress in two springs.
Take G = 83 GN/m^2. **(08 Marks)**

b. A truck spring has 12 numbers of leaves, two of which are full length leaves. The spring supports are 1.05 m apart and the central bond is 85mm wide. The central load is to be 5.4 kN with a permissible stress of 280 N/mm^2. Determine the thickness and width of the steel spring leaves. The ratio of the total depth to the width of the spring is 3. Also determine the deflection of the spring. Take = E = 0.26×10^6 MPa. **(08 Marks)**

Module-3

5 A pair of spur gear with 20° full depth teeth transmits 20 kW at 1500 rpm to the pinion. The speed reduction ratio is 4. Take material for pinion a gear having a permissible static stress of 220 N/mm^2 and 193.2 N/mm^2 respectively. You are required to check the design for dynamic load and prolonged wear. **(16 Marks)**

OR

6 Design a pair of bevel gears at acute angle to transmit 40 kW at 1200 rpm of the pinion with the velocity ratio of 6. Assume C-45 steel for both gears having permissible stress of 233.4 N/mm^2, BHN 200. Take number of teeths on pinion as 25. $\alpha = 14\frac{1}{2}$, $\theta = 45°$. Consider continuous service of medium shocks. **(16 Marks)**

Module-4

7 Design a worm gear drive to transmit 5 kW at 1200 rpm. The speed ratio is to be 25 and the centre distance 250 mm. The worm wheel is made from phosphor bronze with permissible strength of 82.4 N/mm^2 and hardness 100 BHN, while the worm is made from steel 45 with permissible stress 233.4 N/mm^2 and 200 BHN. Load factor (k_l) = 1.25, $\alpha = 14.5°$. **(16 Marks)**

OR

8 a. A differential bond brake shown in Fig.Q8(a) operates on a drum of diameter 600 mm. The bond is 3.2×100mm and coefficient of friction is 0.22. $\theta = 300°$.

(i) Find the force required at the end of operating lever, when the bond is subjected to a stress of 55 N/mm^2.

(ii) Find the torque applied to the brake drum shaft.

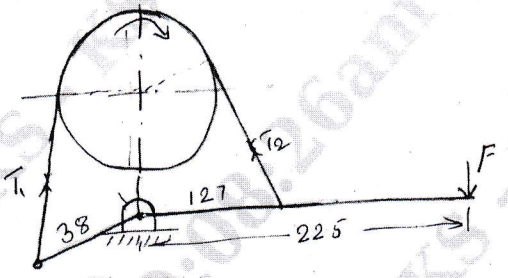

Fig.Q8(a) **(08 Marks)**

b. A cone clutch has a semi-cone angle of 12° to transmit 10 kW of 750 rpm. The width of the face is one fourth of the mean diameter of friction lining. The normal intensity of pressure between the contacting surface is not to exceed 0.85 N/mm^2. Assume uniform wear criterion. $\mu = 0.2$. Calculate dimensions of clutch. Allowable shear stress for shaft material is 40 N/mm^2. **(08 Marks)**

Module-5

9 a. Derive Petroff's equation of lightly loaded bearing. **(08 Marks)**

b. A roller bearing has a dynamic load capacity of 26 kN. The desired life for 90% of the bearing is 8000 hr and the speed is 300 rpm. Calculate the equivalent radial load that the bearing can carry. **(08 Marks)**

OR

10 a. List the factors to be considered while selecting bearing material. **(06 Marks)**

b. A full bearing 200mm diameter by 200mm long supports a radial load 45 kN. The journal rotates at 1200 rpm and r/c = 1000. The viscosity of the oil at its operating temperature of 80°C is 0.1766 N/m^2, ambient temperature is 20°C. Using Raimondi and Boyd curve determine the oil film thickness, coefficient of friction, heat generated in the bearing, Heat dissipated. **(10 Marks)**