B.E. Mechanical Engineering (Model Curriculum) Semester - V

PCC-ME301 - Heat Transfer

P. Pages : 3 **GUG/S/23/14068**

Time : Three Hours * 2 8 0 5 * Max. Marks : 80

Notes :
1. All questions carry equal marks.
2. Assume suitable data wherever necessary.
3. Diagrams and Chemical equation should be given wherever necessary.
4. Illustrate your answers wherever necessary with the help of neat sketches.
5. Use of Non programmable calculator is permitted.
6. Q1 or Q2, Q3 or Q4, Q5 or Q6, Q7 or Q8, Q9 or Q10.
7. Use of slide rule, Logarithmic Tables, Steam Tables, Mollier's Chart, Drawing Instruments, Thermodynamic tables for moist air, Psychometric Charts and Refrigeration charts is permitted. Non programmable calculator is permitted.

1. a) State Fourier's law of heat conduction? Derive expression for temperature distribution under 1 – dimensional steady state heat conduction for plane wall? **8**

b) A steam pipe (k = 45 W/mºC) having 80 mm inside diameter and 90 mm outside diameter is lagged with 2 insulation layer; the layer in contact with the pipe is 30 mm asbestos (k = 0.15 W/m ºC) and is covered with 30 mm thick magnesia insulation (k = 0.075 W/mºC). The heat transfer coefficient for inside and outside surfaces are 200 W/m^2 ºC and 10 W/m^2 ºC respectively. If the temperature of steam is 350 ºC and ambient temperature is 30 ºC, Calculate : i) The steady loss of heat for 50 m length of the pipe; ii) Overall heat transfer coefficients based on inside and outside surface areas of the composite steam pipe. **8**

OR

2. a) Determine the rate of heat flow through spherical boiler wall which is 2.5 m in diameter and 2.5 cm thick steel (k = 60 W/m ºC). The outside surface of boiler wall is covered with asbestos (k = 0.15 W/m ºC) 5 mm thick. The temperature of outer surface and that of fluid inside are 45º C and 350ºC respectively. Take inner and outer heat transfer coefficients as 200 W/m^2 ºC and 8 W/m^2 ºC. **8**

b) Define critical thickness of insulation and Obtain the condition for critical thickness of radius in case of sphere? **8**

3. a) A plane wall is a composite of 2 materials a and b. The wall of material 'a' generates heat at a rate of 2 x 10^6 W/m^2. Thickness of wall a (k = 150 W/m ºC) and b (k = 50 W/m ºC) are 5 cm and 3 cm respectively. The inner surface of wall 'a' is well insulated and outer surface of material 'b' is cooled by water at 30 ºC and 'h' = 1000 W/m^2 ºC. Determine temperature of insulated surface and temperature of cooled surface? **8**

b) Define fin efficiency and fin effectiveness? An engine cylinder is 350 mm in diameter and 250mm long. The longitudinal fins of 10 mm thickness and 40 mm height are proposed. Determine the number of fins required so that engine surface temperature should not exceed 60ºC when dissipating 350 W of heat. Take 'h' = 50 W/m^2 ºC, k of fin material as 45 W/mºC, and atmospheric temperature as 35 ºC. **8**

OR

4. a) A steel tube carries steam at a temperature of 320ºC. A thermometer pocket of iron (k = 50 W/mºC) of inside diameter 15 mm and 1 mm thick is used to measure the temperature. The error to be tolerated is 1.5% of maximum. Estimate the length of the pocket necessary to measure the temperature within this error. Diameter of steel tube is 95 mm. Assume h = 90 W/m^2 ºC and tube wall temperature is 120ºC. **8**

b) A 50 cm x 50 cm copper slab 5 mm thick has a uniform temperature of 300ºC. Its temperature is suddenly lowered to 35ºC. Calculate the time required for the plate to reach the temperature of 150ºC. For copper slab, take (Density = 9000 kg/m^3, c = 380 J/kg. ºC, k = 380 W/m ºC). Assume convective heat transfer coefficient as 90 W/m^2 ºC. **8**

5. a) An oil at 25ºC flows at a velocity of 0.1 m/s past a flat plate 5 m long and maintained at a uniform temperature of 95ºC. Calculate the following using exact solution. **8**
i) Thickness of hydrodynamic and thermal boundary layer on one side of the plate, ii) Total drag force per unit width of the plate on one side of the plate, iii) Avg. convective heat transfer coefficients, iv) Heat transfer rate.
Take properties of oil as :- Density = 950 kg/m3, Thermal diffusivity = $7.2x10^{-8}$ m^2/s; Thermal conductivity = 0.2 W/mºC, kinematic viscosity = $0.65x10^{-4}$ m^2/s.

b) In a straight tube of 60 mm diameter, water is flowing at a velocity of 10 m/s. The tube surface temperature is maintained at 80ºC and flowing water is heated from inlet temperature 20ºC to outlet temperature of 50ºC. Take the properties of eater at temperature 35ºC. Calculate the following:- i) Heat transfer coefficient from tube surface to water; ii) Amount of heat transferred; iii) Length of the tube. **8**

OR

6. a) Define and explain the significance of following dimensionless numbers:- **4**
i) Reynolds Number, ii) Prandtl Number, iii) Grashoff Number

b) Explain with boiling curve, various regimes of saturated pool boiling? **6**

c) Calculate the rate of heat loss from human body which may be considered as a vertical cylinder 30 cm in diameter and 175 cm high in a still air at 25ºC. The skin temperature is 35ºC and emissivity of the skin surface is 0.4. **6**

7. a) State :- (i) Planck's law and Wien's displacement law of radiation? **8**

b) Calculate the following for an industrial furnace in the form of black body and emitting radiation at 2500ºC? **8**

i) Monochromatic emissive power at 1.5μm wavelength

ii) Wavelength at which emission is maximum.

iii) Maximum emissive power,

iv) Fraction of emitted energy in visible range of wavelength.

OR

8. a) The radiation shape factor of circular surface of a thin hollow cylinder of 08 cm diameter and 10 cm length is 0.15. Estimate the shape factor of the curved surface of the cylinder with respect to itself? **8**

b) Consider 2 large parallel plates with emissivity = 0.5 are maintained at different temperatures and are exchanging heat only by radiation. One equally large radiation shield with surface emissivity 0.05 is introduced in parallel to plates. Find the percentage reduction in net radiative heat transfer? **8**

9. a) Derive an expression for LMTD in case of counter flow Heat exchangers? **8**

b) Steam enters a tubes of counter flow heat exchanger, dry saturated at 10 bar and leaves at 350ºC. The mass flow of steam is 800 kg/min. The gas enters a heat exchanger at 650ºC and mass flow rate is 1350 kg/min. If the tubes are 30 mm in diameter and 2mm thick and 3 m long, determine the number of tubes required? Neglect the resistance offered by metallic tube. Take steam side heat transfer coefficient as 600 W/m^2 ºC, and gas side heat transfer coefficient as 250 W/m^2 ºC and Take Cp of gas as 1 kJ/kgºC. **8**

OR

10. a) Derive the expression for effectiveness by NTU method for parallel flow heat exchanger? **8**

b) Steam at atmospheric pressure enters the shell of a surface condenser in which water flows through a bundle of tubes of diameter 25 mm at the rate of 0.05 kg/sec,. the inlet and outlet temperatures of water are 15ºC and 70ºC respectively. The condensation of steam takes place on outside surface of tube. The steam side and water side heat transfer coefficients are 1200 W/m^2 ºC and 100 W/m^2 ºC. **8**
Using NTU method calculate the following:- i) Effectiveness of heat exchanger, ii) Length of the tube, iii) Rate of steam condensation. (hfg at 100ºC = 2257 kJ/kg)

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