MUTHAYAMMAL ENGINEERING COLLEGE

(An Autonomous Institution)

(Approved by AICTE, New Delhi, Accredited by NAAC & Affiliated to Anna University)
Rasipuram - 637 408, Namakkal Dist., Tamil Nadu.

Department of Mechanical Engineering
Question Bank - Academic Year (2019-20)

Course Code & Course Name : 16MED13 Heat and Mass Transfer

Year/Sem/Sec : III/V/A

Unit-I: CONDUCTION
Part-A (2 Marks)

1. State Fourier's Law of conduction
2. Define Thermal Conductivity
3. Write down the equation for conduction of heat through a slab or plane wall.
4. Write down the equation for conduction of heat through a hollow cylinder.
5. State Newton's law of cooling or convection law.
6. Define overall heat transfer co-efficient.
7. Write down the equation for heat transfer through composite pipes or cylinder.
8. What is critical radius of insulation (or) critical thickness?
9. Define fins (or) extended surfaces.
10. State the applications of fins.

Part-B (16 Marks)

1. A wall is constructed of several layers. The first layer consists of masonry brick 20 cm. thick of thermal conductivity 0.66 W/mK, the second layer consists of 3 cm thick mortar of thermal conductivity 0.6 W/mK, the third layer consists of 8 cm thick lime stone of thermal conductivity 0.58 W/mK and the outer layer consists of 1.2 cm thick plaster of thermal conductivity 0.6 W/mK. The heat transfer coefficient on the interior and exterior of the wall are 5.6 W/m^{2}K and 11 W/m^{2}K respectively. Interior room temperature is 22°C and outside air temperature is -5°C. (16)

   Calculate

   a) Overall heat transfer coefficient
   b) Overall thermal resistance
   c) The rate of heat transfer
   d) The temperature at the junction between the mortar and the limestone.

2. A furnace wall made up of 7.5 cm of fire plate and 0.65 cm of mild steel plate. Inside surface

exposed to hot gas at 650°C and outside air temperature 27°C. The convective heat transfer co-efficient for inner side is 60 W/m^2K. The convective heat transfer co-efficient for outer side is $8W/m^2K$. Calculate the heat lost per square meter area of the furnace wall and also find outside surface temperature. (16)

3. A steel tube (K = 43.26 W/mK) of 5.08 cm inner diameter and 7.62 cm outer diameter is covered with 2.5 cm layer of insulation (K = 0.208 W/mK) the inside surface of the tube receivers heat from a hot gas at the temperature of 316°C with heat transfer co-efficient of 28 W/m^2K. While the outer surface exposed to the ambient air at 30°C with heat transfer co-efficient of 17 W/m^2K. Calculate heat loss for 3 m length of the tube. (16)

4. An aluminium alloy fin of 7 mm thick and 50 mm long protrudes from a wall, which is maintained at 120°C. The ambient air temperature is 22°C. The heat transfer coefficient and conductivity of the fin material are 140 W/m^2K and 55 W/mK respectively. Determine
   1. Temperature at the end of the fin.
   2. Temperature at the middle of the fin.
   3. Total heat dissipated by the fin.

5. (i) .A furnace wall consists of three layers. The inner layer of 10 cm thickness is made of firebrick (k =1.04 W/mK). The intermediate layer of 25 cm thickness is made of masonry brick(k = 0.69 W/mK) followed by a 5 cm thick concrete wall (k = 1.37 W/mK). When the furnace is in continuous operation the inner surface of the furnace is at 800°C while the outer concrete surface is at 50°C. Calculate the rate of heat loss per unit area of the wall, the temperature at the interface of the firebrick and masonry brick and the temperature at the interface of the masonry brick and concrete. (8) (8)

   (ii). An electrical wire of 10 m length and 1 mm diameter dissipates 200 W in air at 25°C. The convection heat transfer coefficient between the wire surface and air is 15 W/m2K. Calculatethe critical radius of insulation and also determine the temperature of the wire if it is insulated to the critical thickness of insulation. (8)

Unit-II : CONVECTION

Part-A (2 Marks)

1. Define convection
2. Define Reynolds number (Re) & Prandtl number (Pr)
3. Define Nusselt number (Nu).
4. Define Grash of number (Gr) & Stanton number (St)
5. What is meant by Newtonian and non – Newtonian fluids? .
6. What is meant by laminar flow and turbulent flow?
7. What is meant by free or natural convection & forced convection?
8. Define boundary layer thickness.

9. What is the form of equation used to calculate heat transfer for flow through cylindrical pipes?

10. What is meant by Newtonian and non – Newtonian fluids

Part-B (16 Marks)

1. Air at 20°C, at a pressure of 1 bar is flowing over a flat plate at a velocity of 3 m/s. if the plate maintained at 60°C, calculate the heat transfer per unit width of the plate. Assuming the length of the plate along the flow of air is 2m._Air at 20°C at atmospheric pressure flows over a flat plate at a velocity of 3 m/s. if the plate is 1 m wide and 80°C, calculate the following at x = 300 mm.

    1. Hydrodynamic boundary layer thickness,
    2. Thermal boundary layer thickness,
    3. Local friction coefficient,
    4. Average friction coefficient,
    5. Local heat transfer coefficient
    6. Average heat transfer coefficient,
    7. Heat transfer.

2. Air at 30°C flows over a flat plate at a velocity of 2 m/s. The plate is 2 m long and 1.5 m wide. Calculate the following:

    1. Boundary layer thickness at the trailing edge of the plate,
    2. Total drag force,
    3. Total mass flow rate through the boundary layer between x = 40 cm and x = 85 cm.

3. In a long annulus (3.125 cm ID and 5 cm OD) the air is heated by maintaining the temperature of the outer surface of inner tube at 50°C. The air enters at 16°C and leaves at 32°C. Its flow rate is 30 m/s. Estimate the heat transfer coefficient between air and the inner tube

4. A large vertical plate 4 m height is maintained at 606°C and exposed to atmospheric air at 106°C. Calculate the heat transfer is the plate is 10 m wide. A thin 100 cm long and 10 cm wide horizontal plate is maintained at a uniform temperature of 150°C in a large tank full of water at 75°C. Estimate the rate of heat to be supplied to the plate to maintain constant plate temperature as heat is dissipated from either side of plate.

5. Air at 200 kPa and 200°C is heated as it flows through a tube with a diameter of 25 mm at a velocity of 10 m./sec. The wall temperature is maintained constant and is 20°C above the air temperature all along the length of tube. Calculate :(i) The rate of heat transfer per unit length of the tube.(ii) Increase in the bulk temperature of air over a 3 m length of the tube. (16)

Unit-III : PHASE CHANGE AND HEAT EXCHANGERS

Part-A (2 Marks)

1. What is meant by Boiling and condensation?
2. What is boiling?
3. What is meant by pool boiling?
4. What is meant by Film wise and Drop wise condensation?
5. Give the merits of drop wise condensation?
6. What is heat exchanger?
7. What are the types of heat exchangers?
8. What is meant by Regenerators?
9. What is meant by Fouling factor?
10. What is meant by effectiveness?

Part-B (16 Marks)

1. Water is boiling on a horizontal tube whose wall temperature is maintained ct 15°C above the saturation temperature of water. Calculate the nucleate boiling heat transfer coefficient. Assume the water to be at a pressure of 20 atm. And also find the change in value of heat transfer coefficient when

    1. The temperature difference is increased to 30°C at a pressure of 10 atm.
    2. The pressure is raised to 20 atm at $\Delta T = 15°C$

2. Steam at 0.080 bar is arranged to condense over a 50 cm square vertical plate. The surface temperature is maintained at 20°C. Calculate the following.

    a. Film thickness at a distance of 25 cm from the top of the plate.
    b. Local heat transfer coefficient at a distance of 25 cm from the top of the plate.
    c. Average heat transfer coefficient.
    d. Total heat transfer
    e. Total steam condensation rate.

    What would be the heat transfer coefficient if the plate is inclined at 30°C with horizontal plane

3. . A tube of 2 m length and 25 mm outer diameter is to be used to condense saturated steamat 100°C while the tube surface is maintained at 92°C. Estimate the average heat transfer coefficient and the rate of condensation of steam if the tube is kept horizontal. The steam condenses on the outside of the tube.

4. Steam condenses at atmospheric pressure on the external surface of the tubes of a steam condenser. The tubes are 12 in number and each is 30 mm in diameter and 10 m long. The inlet and outlet temperatures of cooling water flowing inside the tubes are 25°C and 60°C respectively.If the flow rate is 1.1 kg/s, calculate

    (i) The rate of condensation of steam

    (ii) The number of transfer units

    (iii) The effectiveness of the condenser. (16)

5. (i) Discuss the various regimes of pool boiling heat transfer. (8) (ii) Dry saturated steam at a

pressure of 2.45 bar condenses on the surface of a vertical tube of height 1 m. The tube surface temperature is kept at 117°C. Estimate the thickness of the condensate film and the local heat transfer coefficient at a distance of 0.2m from the upper end of the tube. (8)

Unit-IV :

Part-A (2 Marks)

1. State Planck's distribution law.
2. State Wien's displacement law.
3. Define Emissivity
4. State Kirchoff's law of radiation.
5. Define intensity of radiation (I_b).
6. What is the purpose of radiation shield?
7. Define irradiation (G) and radiosity (J)
8. What is meant by shape factor?
9. What is meant by absorptivity, reflectivity and transmissivity?
10. Define emissive power [E] and monochromatic emissive power.

Part-B (16 Marks)

1. A black body at 3000 K emits radiation. Calculate the following:

    i) Monochromatic emissive power at 7 μm wave length.
    ii) Wave length at which emission is maximum.
    iii) Maximum emissive power.
    iv) Total emissive power,
    v) Calculate the total emissive of the furnace if it is assumed as a real surface having emissivity equal to 0.85.

2. Two parallel plates of size 3 m × 2 m are placed parallel to each other at a distance of 1 m. One plate is maintained at a temperature of 550°C and the other at 250°C and the emissivities are 0.35 and 0.55 respectively. The plates are located in a large room whose walls are at 35°C. If the plates located exchange heat with each other and with the room, calculate.

    1. Heat lost by the plates.

    2. Heat received by the room.

3. . A thin aluminium sheet with an emissivity of 0.1 on both sides is placed between two very large parallel plates that ae maintained at uniform temperatures Tl = 800 K and T2 = 500 K and have emissivities £"1 = 0.2 and £"2 = 0.7 respectively. Determine the net rate of radiation heat transfer between the two plates per unit surface area of the plates and compare the result to that without shield. (16)

4. (i) Define emissivity, absorptivity and reflectivity (06)

(ii) Describe the phenomenon of radiation from real surfaces. (10)

5. . (i) Two parallel, infinite grey surface are maintained at temperature of 127C and 227C respectively. If the temperature of the hot surface is increased to 327°C, by what factor is the net radiation exchange per unit area increased? Assume the emissivities of cold and hot surface to be 0.9 and 0.7 respectively. (8) (ii) Two equal and parallel discs of diameter 25 cm are separated by a distance of 50 cm. If the discs are maintained at 600°C and 250°C. Calculate the radiation heat exchange between them. (8)

Unit-V :

Part-A (2 Marks)

1. What is mass transfer?
2. Give the examples of mass transfer.
3. What are the modes of mass transfer?
4. What is molecular diffusion?
5. What is Eddy diffusion?
6. State Fick's law of diffusion.
7. Define Schmidt Number
8. Define Scherwood Number
9. What is convective mass transfer?
10. What is molecular diffusion?

Part-B (16 Marks)

1. The tire tube of a vehicle has a surface area 0.62 m2 and wall thickness 12 mm. The tube

has air filled in it at a pressure 2.4 x 105 N/m2• The air pressure drops to 2.3 x 105 N/m2 in 10 days. The volume of air in the tube is 0.034 m3• Calculate the diffusion coefficient of air in rubber at the temperature of 315K. Gas constant value = 287. Solubility of air in rubber tube = 0.075m3 of air/m3 of rubber tube at one atmosphere (16)

2. . (i) Define mass concentration, molar concentration, mass fraction and mole fraction.(4) (ii)

The diffusivity of CCl4 in air is determined by observing the steady state evaporation of CCl4 in a tube of 1 cm diameter exposed to air. The CCl4 liquid level is 10 cm below the top level of the tube. The system is held at 25°C and 1 bar pressure. The saturation pressure of CCl4 at 25°C is 14.76 kPa. If it is observed that the rate of evaporation of CCl4 is 0.1 kg/hour determine the diffusivity of CC14 into air. (12)

3. (i) A mixture of 02 and N2 with their partial pressures in the ratio 0.21 to 0.79 is in a container

at 25°C. Calculate the molar concentration, the mass density, the mole fraction and the mass fraction of each species for a total pressure of 1 bar. What would be the average molecular weight of the mixture? (8) (ii) Discuss the analogy between heat and mass transfer. (8)

4. . (i) Define the Schmidt ,Sherwood and Lewis numbers. What is the physical significance of each? (8) (ii) Dry air at 27°C and 1 atm flows over a wet flat plate 50 cm long at a velocity of 50 mls. Calculate the mass transfer co-efficient of water vapour in air at the end of the plate. Take the diffusion coefficient of water vapour in air is DAB = 0.26 X 10-4 m2/s. (8)

5. (i) Explain Fick's first and second laws of diffusion. (8)

   (ii) Explain the phenomenon of equimolar counter diffusion. Derive an expression for equimolar counter diffusion between two gases or liquids. (8)

Course Faculty **HoD**