Question Paper

Exam Date & Time: 28-Apr-2018 (09:30 AM - 12:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

INTERNATIONAL CENTRE FOR APPLIED SCIENCES
IV SEMESTER B.S. (ENGG.)
END - SEMESTER THEORY EXAMINATIONS APRIL - 2018
DATE: 28 APRIL 2018
TIME: 9:30 AM TO 12:30 PM
Heat Transfer Operations [CHM 242]

Marks: 100 **Duration: 180 mins.**

Answer 5 out of 8 questions.

1) Derive an expression for the rate of heat flow through a composite cylindrical wall made of several resistances in series, stating the necessary assumptions. (10)

A)

B) A hot gas at 300^{o}C flows through a long metal pipe 10cm OD and 3mm thick. From the standpoint of safety and energy conservation, mineral wool insulation (k = 0.052W/m K) is wrapped around it so that the exposed surface of the insulation is at a temperature of 50^{O}C. Calculate the thickness of insulation required to achieve this temperature if h_i= 29 W/m^2 K, h_o=12 W/m^2 K and surrounding air temperature is 25^{0}C. Also calculate the corresponding heat loss rate per unit length. (10)

2) Determine the individual thermal resistance to calculate overall heat transfer coefficient in a plane wall. (8)

A)

B) An ice-ball of initial diameter 0.06m is suspended in a room at 30^{o}C. The ice melts by absorbing heat from the ambient, the surface heat transfer coefficient being 11.4 W/m^2 ^{o}C. The air in the room is essentially dry. If the shape of the ball remains unchanged, calculate the time required for reduction in its volume by 40%. The density of ice is 929 kg/m^3 and its latent heat of fusion is 3.35 x 10^{5} J/kg. (12)

3) Derive an expression for the heat flow through a rectangular fin (end is insulated) stating all the necessary assumptions (12)

A)

B) Determine the coefficient of water flowing in a tube of (8)

16mm diameter at a velocity of 3 m/s. the temperature of the tube is 297K and water enters at 353K and leaves at 309K.Use (i) Dittus- Boelter equation and (ii) Sieder-Tate equation. Data : Properties of water at 331K i.e at the arithmetic mean bulk temperature are Density - 984.1 Kg/m^3, Specific heat - 4187 J/(kg.k), Viscosity - $485x10^{-6}$ Pa.s, Thermal conductivity - 0.657 W/(m.K), Viscosity of water at 297 K - 920×10^{-6} Pa.s.

4) For forced convection, the heat transfer coefficient 'h' is observed to depend upon the following variables. (10)

A) Velocity of the fluid V. Viscosity of the fluid Âµ. Specific heat of the fluid Cp.
Thermal conductivity of the fluid K. Density of the fluid ρ .
Diameter of the pipe d. Using the dimensional analysis obtain the following relationship Nu=f(Re, Pr).

B) A 1 kW electric room heater has a coil of nichrom wire of diameter 0.574 mm and electrical resistance 4.167 ohm/m. if the temperature of the room remains constant at 21^oC and the average heat transfer coefficient at the surface of the wire is 100 $W/m^{2o}C$, calculate the time required for the heating coil, after it is switched on, to reach 63% of its steady state temperature rise. Assume that the wire itself offers negligible heat transfer resistance. The density of the material of the wire is 8920 kg/m^3, and its specific heat is 384 J /kg ^oC. (10)

5) Describe boiling point curve and different types of boiling. (8)

A)

B) A double pipe parallel flow heat exchanger use oil (Cp = 1.88 KJ/kg.k) at an initial temperature of 205 ^oC to heat water, flowing at 225 kg/hr from 16^oC to 44^oC, the oil flow rate is 270 kg/hr (Cp water = 4.18KJ/kg.k). (12)
a)What is the heat transfer area required for an overall heat transfer co-efficient of $340W/m^2.K$
b)Determine the number of transfer unit (NTU)
c)Calculate the effectiveness of heat exchanger.

6) Explain i) Critical thickness of insulation ii) Optimum thickness of insulation (10)

A) iii) Overall coefficient iv) Dirt Factor.

B) A steam pipe of 97mm inner diameter and 114mm outer diameter (4 inch schedule 80) is required to carry high (10)

pressure saturate steam at 30bar absolute pressure(234^{o}C), it is covered by a layer of mineral wool in order to reduce heat loss through an extra thick layer of insulation saves a lot of heat , it is expensive at the same time as a standard practice a design engineer usually allows the temperature at the outer surface of the insulation (also called the skin temperature) to remain at 15 - 20^{o}C, above room temperature, in order to calculate the thickness of insulation of the above steam pipe, assume a skin temperature of 55^{o}C, the ambient temperature is 30^{o}C, thermal conductivity of mineral wool may be taken as 0.1 W/m ^{o}C and that of pipe material (carbon steel) as 43 W/m ^{o}C, the external air-film co-efficient for heat loss to the ambient is 8 W/m^{2} ^{o}C. Calculate the thickness of insulation and the rate of heat loss per meter length of the pipe.

7) A) Derive an expression for unsteady state heat conduction. State its assumptions. (12)

B) Briefly discus the advantage of shell and tube heat exchanger over a double pipe heat exchanger. (8)

8) A) Derive an expression for the net radiant energy transfer between two infinitely long parallel planes having different emissivity. (10)

B) Find out the heat transfer rate per unit area due to radiation between two infinitely long parallel planes. The first plane has an emissivity of 0.4 and is maintained at 473K. The emissivity of second plane is 0.2 and is maintained at 300K , if a radiation shield having e= 0.5 is introduced between the given planes, find the percentage reduction in heat transfer rate and the steady state temperature attained by the shield. (10)

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