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Question Paper Code: 2035266

B.E. / B.Tech. DEGREE EXAMINATIONS, NOV/ DEC 2024

Fifth Semester

Chemical Engineering

U20CH504 – PROCESS HEAT TRANSFER

(Regulation 2020)

(Use of Steam Tables Permitted)

Time: Three Hours Maximum: 100 Marks

Answer ALL questions

PART – A (10 x 2 = 20 Marks)

1. Define Fourier's law of heat conduction.

2. List the critical insulation thickness for cylinder and sphere.

3. Relate the conditions when Sider- Tate equation is used in heat transfer.

4. Define white body.

5. Is a counter flow heat exchanger more efficient than a parallel heat exchanger? If so why?

6. Define capacity ratio.

7. Compare Drop wise and film wise condensation.

8. Define Leidenfrost point.

9. State Duhring's rule.

10. Explain Vacuum is maintained in the vapor space of the evaporator.

PART – B (5 x 16 = 80 Marks)

11. (a) The wall of a cold storage consists of three layers- an outer layer of ordinary brick, 25 cm thick, a middle layer of cork, 10 cm thick and an inner layer of cement 6 cm thick. The thermal conductivities of the materials are –brick: 0.7, cork: 0.043 and cement: 0.72 W/m°C. The temperature of the outer surface of the wall is 30°C and that of the inner is -15°C. Estimate a) the steady state rate of heat gain per unit area of the wall, b) the temperature at the interface of the composite wall, the percentages of total heat transfer resistance offered by the individual layers. c) What additional thickness of cork should be provided to make the rate of heat transfer 30% less than the present value? (16)

(OR)

(b) Calculate the rate at which heat is being lost to the surrounding per length of an insulated steam pipe having the following dimensions and specifications: (16)

Inner diameter of pipe :30 mm
Thickness of pipe : 2 mm
Thickness of insulation : 10 mm
Heat transfer coefficient on inner side: 11.36 W/m^2K
Temperature of steam :373K
Temperature of the surroundings: 298K
Thermal conductivity of pipe metal:17.44 W/mK
Thermal conductivity of insulation:0.58 W/mK
Heat transfer coefficient on outer side: 9 W/m^2K

12. (a) 0.06kg/s of hot air flows through an un-insulated sheet metal duct of 180mm diameter. The air enters the duct at a temperature of 110°C and after a distance of 4.5 m gets cooled to a temperature of 70°C. If the heat transfer coefficient between the outer surface of the duct and the cold ambient air at 5°C is 6.5 $W/m^2°C$. Evaluate a) The heat loss from the duct over its 4.5m length, b) The heat flux and the duct surface temperature at a length of 4.5 m.
Data: At 90°C, Density :0.972 kg/m^3, Specific heat capacity:1.009 KJ/kg°C, Thermal conductivity ; 0.03127 W/m°C, Kinematic viscosity:22.1 x 10^{-6} m^2/s, Dynamic viscosity: 22.14 x10^{-6} kg/ms, Prandtl number:0.69. (16)

(OR)

(b) Two large parallel planes having emissivities 0.4 and 0.2 are maintained at 473K and 300K respectively. A radiation shield having an emissivity of 0.5 on both the sides is placed between the two planes. Analyze i) the heat transfer rate without the radiation shield, ii) the heat transfer rate per unit area with the radiation shield, iii) the temperature of the shield. (16)

13. (a) 16.5 kg/s of the product at 650°C (C_p= 3.55 kJ/kg°C), in a chemical plant, are to be used to heat 20.5 kg/s of the incoming fluid from 100°C (C_p =4.2 kJ/kg°C). If the overall heat transfer coefficient is 0.95 $kW/m^2°C$ and the installed heat transfer surface is 44 m^2, determine the fluid outlet temperatures for the counter-flow and parallel flow arrangements. (16)

(OR)

(b) Deduce an expression for the Log Mean Temperature and Effectiveness, when the flows of fluids are in counter current pass. (16)

14. (a) Vertical flat plate in the form of fin is 600m in height and is exposed to steam at atmospheric pressure. If the surface of the plate is maintained at 60°C, calculate the following i) the film thickness at the trailing edge of the film, ii) the overall heat transfer coefficient, iii) the heat transfer rate, iv) the condensate mass flow rate. Assume laminar flow conditions and unit width of the plate. The properties of vapour at atmospheric pressure are: T_{sat} = 100°C, h_{fg} =2257 kJ/kg, ρ_v = 0.596 kg/m^3. The properties of saturated vapour at the mean film temperature of 800C are ρ_l = 971.8 kg/m^3, k=67.413 x 10^{-2} W/m°C, μ = 355.3 x 10^{-6} kg/ms. (16)

(OR)

(b) Categorize various regimes of a boiling curve with a neat sketch. (16)

15. (a) An evaporator is operating at atmospheric pressure. It is desired to concentrate a feed from 5% solute to 20% solute by weight at a rate of 5000kg/h. Dry saturated steam at a pressure corresponding to the saturation temperature of 399K is used. The feed is at 298K and the boiling point rise is 5K. The overall HT coefficient is 2350 W/m^{2}K.Calculate the economy of the evaporator and the area of HT to be provided. Treat the solution as pure water and neglect the BPR. (16)

(OR)

(b) Classify the methods of feeding in multiple effects evaporator systems with a neat sketch. State the merits and demerits of methods of feeding. (16)

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