Ref. No. : Ex/FTB/T/223/2018

Name of the Examinations: B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR SECOND SEMESTER - 2018

Subject : HEAT TRANSFER Time : 3 Hrs Full Marks : 100

Part 1 (50 Marks)

Instructions : Use Separate Answerscripts for each Part
Steam Tables may be used.

GROUP I

Answer either question number 1 or 2

1. (a) Starting from Fourier's law of Conduction, develop an expression for conduction in a composite cylinder assuming a pipe of inner and outer radius r_1 and r_2 respectively. The pipe has a layer of insulation of radius r_3 from the centre of the pipe. 10.

(b) A mild steel pipe of internal diameter 50 mm and wall thickness 3 mm is lagged with a 12 mm layer of cork. Calculate the heat loss from the pipe if the inner surface of the pipe is maintained at 420 K and the outer surface at 325 K. The thermal conductivities of mild steel and cork are 45 W/m.K and 0.06 W/m K respectivelv. 10

2. (a) Describe with the help of an experiment how the basic equation of convection, $Q = hA \Delta T$ (where the symbols have their usual significance) has been derived. On what factors does local heat transfer coefficient h depend? 6+4

(b) What is meant by critical thickness of insulation? Show that critical thickness of insulation is a function of heat transfer coefficient of the system and thermal conductivity of the material. What is the significance of Prandtl Number? 2+5+3

Group II

Answer either Question number 3 or 4.

3. Differentiate between evaporation and boiling. Describe how the process of evaporation is important for the food industry. What is evaporator economy? What is boiling point elevation of a solution? Describe with a neat diagram, the operation of a horizontal type natural circulation evaporator. 3+5+2+2+8

4. A 5% solids by mass aqueous food solution flowing at 1.0 kg/s and 288 K is to be concentrated to 30% solids by evaporation in a single effect evaporator. Dry saturated steam at 2 bar is available and the overall heat transfer coefficient is 2.50 $kW/m^2.K$. Assume that the properties of the solution are those of pure water and that the evaporator operates at 0.20 bar. Calculate the rate of steam consumption and the heat transfer area required. Also calculate the steam economy. 20.

[Turn over

GROUP III

Answer either Question number **5 or** 6.

5. With a neat diagram, describe the electromagnetic spectrum clearly indicating the wavelength range of thermal radiation. Differentiate between absorption, reflection and transmission. 7+3

6. Differentiate emissive power of a body from that of its radiosity. What is a black body? Calculate the emissive power of a black body at 1150 ^{o} C by Stephan Boltzmann Law. 3+2+5

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BACHELOR OF ENGINEERING (F.T.B.E) EXAMINATION, 2018

(2^{nd} year, 2^{nd} Semester)

HEAT TRANSFER

Time: 3 hours FM: 100

Part: II

Answers (1a or 1b), (2a or 2b) and (3a or 3b)

1. a) A square slab of butter which is 46.2 mm thick at a temperature of 277.6 k in a coolar is removed and placed at a temperature of 292K. The side and bottom is consider to be insulated. The convective coefficient is constant at 8.52 W/m^2. K. calculates the temperature the temperature of the butter at the surface and at 25.4 mm below the surface after 5 hr of exposer. 10

   b) Perfectly pure liquid in contact with flat heating surface requires infinite time to start boiling-explain and Draw the profile of heat transfer coefficient as against 'quality' during liquid forced convection boiling. 5+5=10

2. a) Saturated steam at 62.1 kPa is condensing on a vertical tube 0.389 m long having an outer diameter of 0.039 m and a surface temperature of 88^0 C. calculate the average heat-transfer coefficient using SI units. Use the following data for properties of water and steam

   T_{sat} =90^0 C, h_{fg} = 2.283×10^6 J/kg, ρ_l =966.7 kg/m^3, ρ_v =0.391 kg/m^3, μ_l = 3.24×10^{-4} Pa.s, κ_l =0.675 W/m.K.

   20

   b) Derive an equation for film condensation coefficient for vertical surface. 20

3. a) A double-tube counter-flow heat exchanger is being used for cooling edible oil. The copper inner tubes have a diameter of 2.0 cm and negligible thickness. The inner diameter of the outer tube is 2.9 cm. Water flows through tube at a rate of 0.55 kg/s, and the oil through the shell at a rate of 0.80 kg/s. Taking the average temperature of water and the oil to be 40^0C and 81^0C, respectively, determine the overall heat transfer coefficient of this heat exchanger.

   The properties of oil and water is constant and as follow
   For water: ρ =990 kg/m^3, κ_l =0.637 W/m.K., $v=\mu/\rho= 0.602 \times 10^{-6}$ m^2 /s, P_r = 3.91
   For edible oil: ρ =852 kg/m^3, κ_l =0.138 W/m.K., $v=\mu/\rho= 3.794 \times 10^{-6}$ m^2 /s, P_r = 499.3
   Consider Nu_i for present Di/Do is 5.42. 20

   b) Describe the design procedure of plate heat exchanger. What do you mean by effectiveness of heat exchanger? How can you estimate pressure drop and heat transfer coefficient in plate heat exchanger? 6+6+8 =20