Ref. No. : Ex/FTB/T/222/2019

Name of the Examinations: B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR SECOND SEMESTER - 2019

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

Part I (50 Marks)

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

Answer any two Questions from 1-4 and any one between 5 and 6.

1. (a) What is the basic difference between the three modes of heat transfer- conduction, convection and radiation? Deduce an equation for heat flux in a steady state heat conduction in a single uniform rectangular slab. 5+5

(b) Steam at 100 ^{0}C condenses on the outside of an alloy tube (thermal conductivity= 182 W/mK) through which water flows at a velocity such that the tube side film heat transfer coefficient is 4100 W/m^2.K. The film heat transfer coefficient for the condensing steam may be taken as 9000 W/m^2.K. The tube is 6 m long, has an external diameter of 20 mm and a wall thickness of 1 mm. Calculate the rate of heat transfer to the water. 10.

2. (a) Explain how the concept of heat transfer coefficient can be developed through the example of water boiling in a vessel over a flame. On what factors do the heat transfer coefficient depend? 8+2

(b) Derive an expression for critical thickness of insulation in a radial pipeline. 10

3. A fluid is flowing in a turbulent flow at a velocity,v, inside a pipe of diameter, D and undergoing heat transfer to the wall. Derive an expression for the phenomenon correlating heat transfer coefficient, h, to the variables D,ρ,μ, C_p, k and v where the symbols have their usual meanings. 20

4. An aqueous food solution at a temperature of 20^{0}C contains 7% solids by mass and it is concentrated to 24% solids in a single effect evaporator. The evaporator has a total heat transfer surface area of 28 m^2, uses steam at 300 kPa and operates under a vacuum of 80 kPa.. the overall heat transfer coefficient is 2300 W/m^2.K. Calculate the mass flow rate of steam required and the evaporator economy. 20

5. With a neat diagram explain the operation of climbing film evaporator. 10

6. (a) What are the differences in absorptivity and reflectivity on a rough(unpolished surface) and a smooth (polished) surface? What does the Stefan Boltzmann law state? Determine the total emissive power of a black body at 1055 ^{0} C? 5+2+3

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BACHELOR OF ENGINEERING (F.T.B.E) EXAMINATION, 2019

(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 meat which is 40 mm thick at a temperature of 255 k in a coolar is removed and placed at a temperature of 292K. The side and bottom is considered to be insulated. The convective coefficient is constant at 10.52 W/m^2. K. calculates the temperature of the meat at the surface and at 20 mm below the surface after 4 hr of expose. 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) Steam condensing on a vertical tube 0.40 m long having an outer diameter of 0:032 m and a surface temperature of 87^0 C. If steam saturated at 75 kPa, 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} = $2.283x10^6$ J/kg, ρ_l =966.7 kg/m^3, ρ_v =0.391 kg/m^3, μ_l = $3.24x10^{-4}$ Pa.s, κ_l =0.675 W/m.K.

   20

   b) In case of vertical surface, derive an equation for film condensation coefficient. 20

3. a) A1-2 heat exchanger containing one shell pass and two tube passes heats 2.52 kg/s of water from 21.1 to54.5 ^{0} C by using hot water under pressure entering at 115.6 and leaving at 48.9^0 C. the outside surface area of the tube in the exchanger is A_0 = 9.30 m^2.

   Calculate the mean temperature difference in the heat exchanger and the overall heat transfer coefficient. You can consider well known value of the different parameter for this purpose. 20

   b) What do you mean by Log-Mean-Temperature-Deference correction factor? How can you change heat transfer coefficient if the velocity of the fluids change over the plate through which the heat is being transferred. What do you mean by effectiveness of heat exchanger? 6+8+6 =20