B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR
FIRST SEMESTER SUPPLEMENTARY EXAM 2023

HEAT TRANSFER

Time: 3 hours FM: 100

(50 marks for each part)
Use a separate Answer-Script for each part

PART I (50 Marks)

(Answer question no 4 and any two from the rest)

1. Draw the boiling curve of a pool of liquid in contact with a horizontally heated surface and label properly indicating different regimes. What do you mean by effectiveness of heat exchanger?
   A square slab of butter which is 46.2 mm thick at a temperature of 277.6 k in a cooler 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. 5+15=20

2. Describe the design procedure of shell and tube heat exchanger. 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. 10+5+5=20

3. Rice Bran oil is to be cooled in a double-tube counter-flow heat exchanger. The copper inner tubes have a diameter of 1.9 cm and negligible thickness. The inner diameter of the outer tube is 2.9 cm. Water flows through tube at a rate of 0.50 kg/s, and the oil through the shell at a rate of 0.85 kg/s. Taking the average temperature of water and the oil to be 45^{0}C and 80^{0}C, respectively, determine the overall heat transfer coefficient of this heat exchanger.
   a. The properties of oil and water is constant and as follow
   b. For water: ρ =990 kg/m^3, κ_l =0.637 W/m.K., v=μ/ρ= 0.602x10^{-6} m^2 /s, P_r = 3.91
   c. For Rice Bran oil: ρ =852 kg/m^3, κ_l =0.138 W/m.K., v=μ/ρ= 3.794x10^{-6} m^2 /s, P_r = 499.3
   d. Consider Nu_i for present Di/Do is 5.42

   Discuss how do fouling factor affects heat transfer. 15+5=20

4. 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

Ref. No.: Ex/FTBE/BS/B/T/217/2023(S)

B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER SUPPLEMENTARY EXAM 2023

HEAT TRANSFER

Full Marks: 100 **Time: 3hrs**

PART II (50 Marks)

Group-A

Answer any one question **1×10 =10**

1. Write the Furier's laws of heat transfer. Define thermal conductivity and write its unit. How thermal conductivity is affected by temperature. 5+3+2 = 10
2. Define absobtivity, ideal black body and heat transfer coefficient, shape factor, natural convective heat transfer. 10

Group-B

Answer any two questions **2×20 =40**

3. (a) Derive equation for conductive heat transfer through a composite slab.

   (b) A brick wall of 20 cm thickness has thermal conductivity of 0. 7 W m^{-1} K^{-1}. An insulation of thermal conductivity 0.2 W m^{-1} K^{-1} is to be applied on one side of the wall, so that the heat transfer through the wall is reduced by 75%. The same temperature difference is maintained across the wall before and after applying the insulation. Calculate the required thickness (in cm) of the insulation. 10+10 = 20

4. (a) Derive the equation for overall heat transfer coefficient. Define the fouling factor. 8+2 =10

   (b) Applesauce is being cooled from 80◦C to 20◦C in a swept surface heat exchanger. The overall coefficient of heat transfer based on the inside surface area is 568 W/m2· K. The applesauce has a specific heat of 3187 J/kg · K and is being cooled at the rate of 50 kg/h. Cooling water enters in countercurrent flow at 10◦C and leaves the heat exchanger at 17◦C. Calculate: (a) the quantity of cooling water required; (b) the required heat transfer surface area for the heat exchanger. 10

5. (a) Write short note on Stephan-Boltzman law and Kirchoff's law. 6+4 = 10

   (b) Cookies traveling on a conveyor inside a continuous baking oven. occupy most of the area on the surface of the conveyor. The top wall of the oven directly above the conveyor has an emissivity of 0.92, and the cookies have an emissivity of 0.8. If the top wall of the oven has a temperature of 175◦C, calculate the average rate of heat transfer by radiation between the cookies per unit area on the side that faces the top wall of the oven when the cookie surface temperature is 70◦C. 10