Ref. No.: Ex/FTBE/BS/B/T/217/2024

B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING
SECOND YEAR FIRST SEMESTER EXAM 2024

HEAT TRANSFER

Full Marks: 100 (Use separate Answer Script for each Part) **Time: 3 hrs**

Part-I (50 Marks)

Group-A

Answer any one question **5×1 =5**

1. Write the Fourier's laws for conductive heat transfer. Define thermal conductivity and thermal diffusivity. 3+2 =5
2. Derive the expression for overall heat transfer coefficient.

Group-B

Answer any three questions **15×3 =45**

3. (a) Derive the expression for heat transfer through multilayer tube.

   (b) How many inches of insulation would be required to insulate a ceiling such that the surface temperature of the ceiling facing the living area is within 2°C of the room air temperature. Assume a heat transfer coefficient on both sides of the ceiling of 2.84 W/(m^2 · K) and a thermal conductivity of 0.0346 W/(m · K) for the insulation. The ceiling is 1.27-cm-thick plasterboard with a thermal conductivity of 0.433 W/(m · K). Room temperature is 20°C and attic temperature is 49°C.

   7+8 = 15

4. (a) Enumerate Lambert,s law for radiation heat transfer.

   (b) Glass bottles may be prevented from breaking on filling with hot pasteurized juice when their temperature is close to that of the juice being filled. The bottles are rapidly heated by passing through a chamber that has top, bottom, and side walls heated by natural gas. The glass bottles may be considered as an object completely surrounded by a radiating surface. The glass bottles have an emissivity of 0.94, a mass of 155 g each, a specific heat of 1256 J/(kg · K), and a surface area of 0.0219 m^2. If the glass bottles are to be heated from 15.5°C to 51.6°C in 1 minute, calculate the temperature of the walls of the chamber to achieve this average heating rate when the glass is at the midpoint of the temperature range (33.6°C). 7+8 = 15

5. (a) Derive the heat transfer equation for unsteady state heat transfer in conduction process.

   (b) Calculate the overall heat transfer coefficient for a 1-in. (nominal) 16-gauge heat exchanger tube when the heat transfer coefficient is 568 W/(m^2 K) inside and 5678 W/(m^2· K) on the outside. The tube wall has a thermal conductivity of 55.6 W/(m·K). The tube has an inside diameter of 2.21 cm and a 1.65 mm wall thickness. (b) If the temperature of the fluid inside the tube is 80°C and 120°C on the outside, what is the inside wall temperature? 5+10 = 15

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6. Derive the expression for LMTD. What is the significance of the Prandtl number? Express the correlations between Nusselt number, Prandtl number and reylonds number in forcer convective heat transfer under steady state condition. What is Grashof number? Write its significance.
7+2+3+3 = 15

7. (a) Write short note on Stephan-Boltzman Law for radiative heat transfer.
   (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 $W/m^2 \cdot K$. 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. 6+9 = 15

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B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAM 2024

Subjects: HEAT TRANSFER

Time: 3 hours FM: 100

Part: II (50)

Answer question no 1 and any two from the following

1. A square slab of butter which is 46.2 mm thick at a temperature of 275.6 k in a coolar is removed and placed at a temperature of 298K. 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 4hr of exposer. 10

2. Derive an equation for film condensation coefficient for vertical surface. 20

3. Discuss the process of pasteurisation of milk (with suitable diagram) using plate heat exchanger having regeneration section. 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

4. In a steam jacketed pan explain the position of steam inlet pipe and water outlet pipe.

   Steam condensing on a vertical tube 0.40 m long having an outer diameter of 0.03 m and a surface temperature of 87^0 C. If steam saturated at 70.1 kPa, calculate the average heat-transfer coefficient using SI units. Use the following data for properties of water and steam Tsat =900 C, hfg = 2.283x106 J/kg, ρl =966.7 kg/m3, ρv =0.391 kg/m3, μl = 3.24x10-4 Pa.s, κl =0.675 W/m.K. 5+15=20