Bihar Engineering University, Patna

B.Tech. 5th Semester Examination, 2023

Course: B.Tech. *Time: 03 Hours*

Code: 102502 *Subject: Heat Transfer* *Full Marks: 70*

Instructions:-

(i) The marks are indicated in the right-hand margin.
*(ii) There are **NINE** questions in this paper.*
*(iii)Attempt **FIVE** questions in all.*
(iv) Question No. 1 is compulsory.
(v) Assume data suitably, if not given

Q.1 Choose the correct answer to the following (Any seven questions only): **[2 × 7 = 14]**

(a) Transfer of heat through electromagnetic waves is known as
(i) Conduction (ii) convection
(iii) Radiation (iv) all of the above

(b) Which of the following is correct regarding one dimensional heat transfer
(i) Steady-f(x,y, t), Unsteady- f(x) (ii) Steady-f(y, z), Unsteady- f(y)
(iii) Steady-f(x,t), Unsteady- f(x) (iv) Steady-f(x), Unsteady- f(x,t)

(c) Why fins are provided on a heat transfer surface?
(i) Pressure turbulence of the fluid should be minimized,
(ii) Increase turbulence in flow for enhancing heat transfer,
(iii)Surface are is maximum to promote the rate of heat transfer
(iv)Increase temperature gradient so as to enhance heat transfer,

(d) Prandtl number is the ratio of:
(i) Momentum diffusivity to mass diffusivity
(ii) Momentum diffusivity to thermal diffusivity
(iii)thermal diffusivity to mass diffusivity
(iv)thermal diffusivity to specific heat

(e) The SI unit of thermal diffusivity is
(i) $Wm^{-2}K^{-1}$ (ii) WmK^{-1} (iii) $Wm^{-1}K^{-1}$ (iv) WmK

(f) In which of the following cases provision of fins on a given heat transfer surface will be more effective?
(i) Fewer but thin fins (ii) Large number of thin fins
(iii) Large number of thick fins (iv) Fewer but thick fins

(g) In spite of the large heat transfer coefficient in boiling liquids, fins are used advantageously when the entire surface is exposed to
(i) Nucleate boiling (ii) Film boiling
(iii) Transition boiling, (iv) All modes of boiling

(h) Which of the following statements are not true about fouling in a Heat Exchanger?
(i) Pressure drop decreases
(ii) Efficiency decreases
(iii) It decreases the heat transfer coefficient in both sides
(iv) Temperature of the hot fluid remains hot and the cold fluid remains cold

(i) If UD = Overall Dirt Transfer coefficient and UC = Overall Clean Heat Transfer coefficient, then which of the following relation is correct?
(i) $U_D < U_C$ (ii) $U_D >> U_C$ (iii) $U_D = U_C$ (iv) $U_D > U_C$

(j) To which side given below should we add fins?
(i) Liquid side (ii) Gas side (iii) Any side possible (iv) Solid side

Q.2 (a) Derive the three-dimensional differential equation for heat conduction for constant thermal conductivity with appropriate assumption [7]

$$\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}+\frac{q}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial \tau}$$

(b) Air at 20 °C blows over a hot plate 50 by 75 cm maintained at 250 °C. The convection heat transfer coefficient is 25 W/m^2. Assuming this plate is made of carbon steel (1%) 2 cm thick and that 300W is lost from the plate surface by radiation, calculate the inside temperature. Given, k = 43 W/m.°C. [7]

Q.3 (a) Define the phenomena of boiling. Draw and explain the boiling heat regime for water electrically heated by platinum wire submerged in water. [7]

(b) Define condensation. Differentiate between dropwise and film wise condensation with appropriate diagram. [7]

Q4 (a) What is the role of baffles in a shell and tube heat exchanger? How does the presence of baffles affect the heat transfer and the pumping requirement? Explain. [7]

(b) Air entering 2 bar pressure and bulk temperature of 200 °C is heated as it flows through a tube a diameter of 25.4 mm at a velocity of 10 m/s. Calculate the heat transfer per unit length of the tube if constant heat flux condition is maintained at the wall and wall temperature is 20 °C above the air temperature all along the length of the tube. How much would the bulk temperature increase over 3 meters length of the tube? [7]

Take the properties of air as: ρ=1.493 kg/m^3, μ= 2.57×10^{-5} Ns/m^2, k = 0.0386 W/m°C, c_p =1025 J/kg°C.

Q.5 (a) What do you understand by critical radius of insulation? Derive expression for critical radius of insulation for sphere and cylinder. [7]

(b) What is Fourier Law of heat conduction? What is Newton's Law of cooling? Using both the laws derive expression for heat transfer for hollow cylinder being cooled by surrounding air. [7]

Q. 6 (a) What do you understand by view factor? Determine the view factors associated with an enclosure formed by two concentric spheres of radius R_1 and R_2. [7]

(b) Prove that there will be 50% reduction in the loss of radiant energy by putting a radiation shield between the wall if the emissivity of the wall and shield are all equal. [7]

Q.7 (a) Draw diagram of triple effect evaporator (backward feed). Define steam economy and capacity for multiple effect evaporator. Also explain the boiling point evaporation. [7]

(b) Define the terms effectiveness and NTU for heat exchanger. Derive expression of NTU for heat exchanger of parallel flow type. [7]

Q.8 (a) What are the common causes of fouling in a heat exchanger? How does fouling affect heat transfer and pressure drop? [7]

(b) A counter-flow double pipe heat exchanger using superheated steam is used to hot water at the rate of 10500 kg/h. The steam enters the heat exchanger at 180 °C and leaves at 130 °C. The inlet and exit temperature of water are 30 °C and 80 °C respectively. If overall heat transfer coefficient from steam to water is 814 W/m^{2o}C, calculate the heat transfer area. What would be the increase in area of the fluid flows were parallel? [7]

Q.9 Write short notes on ***any four*** of the following [3.5×4=14]

(a) Kirchoff's law of radiation. (b) Black body (c) Fin effectiveness and efficiency
(d) Solar radiation (e) Analogy between heat transfer and electrical flow