Register No: …… Name: .....

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

FOURTH SEMESTER B.TECH DEGREE EXAMINATION(R,S), MAY 2024

Chemical Engineering

(2020 SCHEME)

Course Code : 20CHT204

Course Name : Heat Transfer Operations

Max. Marks : 100 **Duration:3 Hours**

Scientific calculator and statistical table is allowed in the examination hall.
Attested copy of heat transfer data sheet and correlation table are allowed in the examination hall.

PART A

(Answer all questions. Each question carries 3 marks)

1. Define and write the expression for dimensionless time (τ).
2. Differentiate between thermal conductivity and thermal diffusivity.
3. Draw the thermal bounday layer and velocity boundary layer diagram for the flow of fluid inside a cylindrical pipe.
4. Define Reynolds number and mention its significance.
5. Draw the velocity profile and temperature profile of fluid during film condensation on a vertical plate.
6. Explain the phenomenon of thermal radiation.
7. List out the factors affecting the selection of a heat exchanger.
8. What are the common causes of fouling in heat exchanger? How does fouling affect heat transfer and pressure drop?
9. Write a short note on boiling point elevation.
10. A 50 kg mass of copper at 70°C is dropped into an insulated tank containing 80 kg of water at 25°C. Determine the final equilibrium temperature in the tank.

PART B

(Answer one full question from each module, each question carries 14 marks)

MODULE I

11. Derive Fourier-Biot equation of three dimensional heat conduction in a spherical object with thermal conductivity 'k' and radius 'r'. Also highlight the special cases of heat conduction. 14

OR

12. Steam at 320°C flows in a stainless steel pipe (k = 15 W/m·°C) whose inner and outer diameters are 5 cm and 5.5 cm, respectively. The pipe is covered with 3-cm-thick glass wool insulation (k = 0.038 W/m·°C). Heat is lost to the surroundings at 5°C by natural convection and radiation, with a combined natural convection and radiation heat transfer coefficient of 15 W/m^2·°C. Taking the heat transfer coefficient inside the pipe to be 80 W/m^2·°C, determine the rate of heat loss from the steam per unit length of the pipe. Also determine the temperature drops across the pipe shell and the insulation. 14

MODULE II

13. During a cold winter day, wind at 55 km/h is blowing parallel to a 4-m-high and 10-m-long wall of a house. If the air outside is at 5°C and the surface temperature of the wall is 12°C, determine the rate of heat loss from that wall by convection. What would your answer be if the wind velocity was doubled? 14

OR

14. Consider the flow of oil at 10°C in a 40-cm-diameter pipeline at an average velocity of 0.5 m/s. A 300-m-long section of the pipeline passes through icy waters of a lake at 0°C. Measurements indicate that the surface temperature of the pipe is very nearly 0°C. Disregarding the thermal resistance of the pipe material, determine (a) the temperature of the oil when the pipe leaves the lake and (b) the rate of heat transfer from the oil. 14

MODULE III

15. Illustrate the various boiling regimes and the effect of ΔT_{excess} on heat flux during pool boiling of water at 1 atm. 14

OR

16. Water is to be boiled at atmospheric pressure in a mechanically polished steel pan placed on top of a heating unit. The inner surface of the bottom of the pan is maintained at 110°C. If the diameter of the bottom of the pan is 25 cm, determine
(a) the rate of heat transfer to the water and (b) the rate of production of vapour. 14

MODULE IV

17. A double-pipe parallel-flow heat exchanger is to heat water (Cp = 4180 J/kg·°C) from 25°C to 60°C at a rate of 0.2 kg/s. The heating is to be accomplished by geothermal water (Cp = 4310 J/kg·°C) available at 140°C at a mass flow rate of 0.3 kg/s. The inner tube is thin-walled and has a diameter of 0.8 cm. If the overall heat transfer coefficient of the heat exchanger is 550 W/m^2·°C, determine the length of the heat exchanger required to achieve the desired heating. 14

OR

18. Cold water (Cp = 4180 J/kg·°C) enters a thin-walled double-pipe counter-flow heat exchanger at 15°C at a rate of 0.25 kg/s and is heated to 45°C by hot water (Cp = 4190 J/kg·°C) that enters at 100°C at a rate of 3 kg/s. If the overall heat transfer coefficient is 950 W/m^2·°C, determine the rate of heat transfer and the heat transfer surface area of the heat exchanger using the NTU method. 14

MODULE V

19. Draw the three different feed flow arrangements in multiple effect evaporator and explain their features. 14

OR

20. Explain the material and energy balance in a tripple effect evaportaor with backward feed using a neat diagram. 14

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