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Code No: 126VF

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B. Tech III Year II Semester Examinations, February - 2023
HEAT TRANSFER
(Mechanical Engineering)

Time: 3 Hours **Max. Marks: 75**

Note: i) Question paper consists of Part A, Part B.
ii) Part A is compulsory, which carries 25 marks. In Part A, Answer all questions.
iii) In Part B, Answer any one question from each unit. Each question carries 10 marks and may have a, b as sub questions.

PART – A

(25 Marks)

1.a) How many boundary conditions are needed to solve a second-order differential equation of heat conduction? [2]
b) Explain the concept of driving potential as applied to heat transfer problems. [3]
c) What is meant by thermal resistance? Explain the electrical analogy for solving heat transfer problems. [2]
d) Explain the following: (i) One-dimensional heat conduction. (ii) Log mean area a s applied to a hollow cylinder. [3]
e) Define Nusselt, Reynolds, Prandtl and Stanton numbers. Explain their significance in forced convection. [2]
f) What is the Dittus-Boelter equation? Where and when does it apply? [3]
g) What is the hydraulic diameter? When it is used? [2]
h) What are the different methods of determining heat transfer coefficient in forced convection? [3]
i) What is LMTD correction factor? [2]
j) Define heat exchanger effectiveness and explain its significance. [3]

PART – B

(50 Marks)

2. A rectangular region $0 \leq x \leq L$, $0 \leq y \leq W$ is maintained at the following conditions. The boundary at y= 0 is at a uniform temperature T, and the boundary at y = W is dissipating heat by convection into a medium at a temperature T. The boundary surface at x=0 and x = L are insulated. Write the mathematical formulation of the steady state heat conduction problem. [10]

OR

3.a) A furnace is to be designed for a maximum wall temperature of 500 ^{0} The hot gas temperature on one side of the wall is 1000 ^{0}C and the air temperature on the other side is 30^{0}C. The value of h for hot side and cold side are 232.6 and 348.9 W/m^2 ^{0}C respectively. Calculate the permissible thermal resistance per m² area of the metal wall.
b) A wire 10 cm long and 1 mm in diameter is taut between two conducting supports in a water tank and is submerged. A controlled amount of current through a variac is passed through the wire until the water boils at 100 ^{0}C. Calculate the steady temperature of the wire if 22 watts of electric power is consumed. Take h =5000 W/m² ^{0}C. [5+5]

4. A rod of length L has one end maintained at temperature T_o and is exposed to an environment at temperature T. An electrical heating element is placed in the rod so that heat is generated uniformly along the length at a rate of Q. Derive an expression (a) for the temperature distribution in the rod (b) for the total heat transferred to the environment. Also obtain an expression for the value of which will make the heat transfer zero at the end which is maintained at T_o. [10]

OR

5. A large mass of a material, for which a = 0.003 m²/h and k = 1.4 W/mK, is initially at 400^0C throughout, suddenly its surface temperature is lowered and permanently held at 40^0C. Determine: (a) the temperature 2.5 cm below the surface after 5 minutes. (b) The quantity of heat passed through the above plane within first two hours. (c) Time required to lower the temperature to 200^0C at a point 2.5 cm below the surface. [10]

6.a) Atmospheric air is contained between two 0.5 m square vertical plates separated by a gap of 15 mm. The two plates are maintained at 100 ^{0}C and 40^0C respectively. Determine the rate of heat transfer across the air space.

b) One surface of a panel 0.915 m × 0.915 m is insulated and the other surface is kept at a uniform temperature of 65.6 ^{0}C. Calculate the mean heat transfer coefficient due to free convection between the heated surface of the panel and the atmospheric air at 10 ^{0}C when (i) heated surface is vertical. (ii) Panel is horizontal with the hot surface facing up. (iii) Panel is horizontal with the hot surface facing down. [4+6]

OR

7.a) Water flows through a tube of 22 mm diameter with a velocity of 2 m/s. Steam at 150^0C is being condensed on the outer surface of the tube thereby raising temperature of water flowing inside the tube from 15 ^{0}C to 60 ^{0}C. Find the heat transfer coefficient and the length of the tube required to meet the above requirement of heat. The resistances of tube and film may be neglected.

b) Hot air at 103 ^{0}C flows through a duct of 15 cm diameter with a mass flow rate of 0.05 kg/s. The temperature of air at a distance of 5 m from entry has been measured to be 77 ^{0}C. The duct is losing heat at 0 ^{0}C with a heat transfer coefficient of 6 W/m K. Neglecting the duct wall resistance, calculate the heat loss from the duct over the 5 m length. Also estimate the heat flux and the surface temperature at x=5 m. [5+5]

8.a) For laminar film condensation, what is the ratio of heat transfer to a horizontal tube of large diameter to that to a vertical tube of the same size for the same temperature difference? What L/D ratio will produce the same rate of heat transfer to a tube in both the vertical and horizontal orientations?

b) A steam-water heat exchanger contains 218 vertical tubes each of 1.6 cm O.D. and 1.5 m long. Dry steam at a pressure of 1 MPa condenses on the outside surface of tubes which is maintained at a temperature of 173 ^{0}C by circulation of cooling water through the tubes. Calculate the amount of heat transfer in this exchanger. [5+5]

OR

9. A boiler furnace lagged with plate steel (ε = 0.6) is laid with fire clay brick (ε = 0.8) on the inside. The distance between the lagging and setting brick is 300 mm and it may be assumed small compared with the size of the furnace. Calculate the loss of heat per unit area between the lagging and setting if these are at 400 K and 323 K respectively. A radiation shield of emissivity 0.6 is now introduced between the brick setting and lagging of the furnace. Compute the radiating flux between these and the loss of heat by radiation to surroundings. [10]

10.a) Water at the rate of 4080 kg/h is heated from 35 ^{0}C to 75^{0}C by an oil having a specific heat of 1900 J/kgK. The exchanger is of a counter flow double pipe design. The oil enters at 110^{0}C and leaves at 75^{0}C. Determine the area of the heat exchanger necessary to handle this load if the overall heat transfer coefficient is 320 W/m²K.

b) A heat exchanger of total outside surface area of 17.5 m^2 is to be used for cooling oil with a mass flow rate of 2.77 kg/s having a specific heat of 1.9 kJ/kgK. Water at a flow rate of 0.83 kg/s is available at 20 ^{0}C as a cooling agent. Calculate the exit temperature of the oil if the heat exchanger is operated in a (i) parallel flow mode. (ii) Counter flow mode. Take U= 300 W/m²K. [5+5]

OR

11.a) An oil cooler, of the concentric tube type is used for cooling oil at 65.6 ^{0}C to 54.4 ^{0}C with water at 26.7^{0}C with a temperature rise of 11.1^{0}C. Assuming an overall heat transfer coefficient of 738 W/m^{2}K based on the outside area of the tubes, determine the heat transfer surface area required for a design heat load of 190.5 kW for a single pass (i) parallel flow mode and (ii) counter flow mode.

b) Water at the rate of 40 kg/min is entering a counterflow double pipe heat exchanger at 35^{0}C. It is heated by an oil having a specific heat of 1900 J/kg K. If the rate of flow of oil is 171 kg/min and its entry temperature is 110 ^{0}C, calculate the exit temperature of water for a total exchanger area of 15.82 m². [5+5]

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