R16

Code No: 136CA

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

B. Tech III Year II Semester Examinations, July - 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)	Define critical thickness.	[2]
b)	State the second law of thermodynamics and its significance.	[3]
c)	Define effectiveness of a fin.	[2]
d)	List the factors affecting thermal conductivity.	[3]
e)	What is drag coefficient?	[2]
f)	Differentiate between the internal and external flow.	[3]
g)	Write the expression for Grashoff number and mention its significance.	[2]
h)	Classify the heat exchangers based on the relative direction of fluid flow.	[3]
i)	State Stefan-Boltzmann law.	[2]
j)	What are the factors affecting nucleate boiling?	[3]

PART – B

(50 Marks)

2.a) Explain the different modes of heat transfer with a suitable example.

b) A steel pipe with 50 mm OD is covered with a 6.4 mm asbestos insulation [k = 0.166 W/mk] followed by a 25 mm layer of fiber-glass insulation [k= 0.0485 W/mk]. The pipe wall temperature is 393 K and the outside insulation temperature is 311 K. Calculate the interface temperature between the asbestos and fiber-glass. [5+5]

OR

3.a) A reactor's wall, 320 mm thick, is made up of an inner layer of fire brick (k=0.84 W/m^{0}C) covered with a layer of insulation (k = 0.16 W/m^{0}C). The reactor operates at a temperature of 1325^{0}C and the ambient temperature is 25^{0}C.
i) Determine the thickness of fire brick and insulation which gives minimum heat loss;
ii) Calculate the heat loss presuming that the insulating material has a maximum temperature of 1200^{0}C.
If the calculated heat loss is not acceptable, then state whether addition of another layer of insulation would provide a satisfactory solution.

b) Derive general heat conduction equation in cylindrical coordinates. [5+5]

4.a) The initial uniform temperature of a large mass of material ($\alpha = 0.42\ m^2/h$) is 120^0C. The surface is suddenly exposed to and held permanently at 6^0C. Calculate the time required for the temperature gradient at the surface to reach $400^0C/m$.

b) One end of a long rod, 35 mm in diameter, is inserted into a furnace with the other end projecting in the outside air. After the steady state is reached, the temperature of the rod is measured at two points 180 mm apart and found to be 180^0C and 145^0C. The atmospheric air temperature is 25^0C. If the heat transfer coefficient is 65 $W/m^2\ ^0C$, calculate the thermal conductivity of the rod. [5+5]

OR

5.a) Derive an expression for temperature distribution and heat transfer rate through the fin insulated at the tip.

b) A mercury thermometer placed in oil well is required to measure temperature of compressed air flowing in a pipe. The well is 140 mm long and is made of steel ($k = 50\ W/m^0C$) of 1 mm thickness. The temperature recorded by the well is 100^0C while pipe wall temperature is 50^0C. heat transfer coefficient between the air and well wall is 30 $W/m^2\ ^0C$. estimate true temperature of air. [5+5]

6.a) Derive a differential convection equation for continuity equation.

b) A flat plate, 1m wide and 1.5 m long is to be maintained at 90^0C in air with a free stream temperature of 10^0C. Determine the velocity with which air must flow over flat plate along 1.5 m side so that the rate of energy dissipation from the plate is 3.75 KW. Considering the following properties of air at 50^0C: $\rho = 1.09\ kg/m^3$; $k = 0.028\ W/m^0C$; $c_p = 1.007\ kJ/kg^0C$; $\mu = 2.03 \times 10^{-5}\ kg/m\text{-}s$ Pr = 0.7. [5+5]

OR

7.a) What are the boundary layer parameters for different velocity profiles using Von Karman Integral Momentum Equation?

b) Air at 30^0C flows with a velocity of 2.8 m/s over a plate 1000 mm (length) × 600 mm (width) × 25 mm (thickness). The top surface of the plate is maintained at 90 ^0C. If the thermal conductivity of the plate material is 25 $W/m\ ^0C$, Calculate:

i) Heat lost by the plate;

ii) Bottom temperature of the plate for the steady state condition.

The thermos-physical properties of air at mean film temperature $(90+30)/2 = 60^0C$ are: $\rho = 1.06\ kg/m^3$; $k = 0.02894\ W/m\ ^0C$; $c_p = 1.005\ kJ/kg\ K$; $v = 18.97 \times 10^{-6}\ m^2/s$; Pr = 0.696. [5+5]

8.a) In a certain double pipe heat exchanger hot water flows at a rate of 5000 kg/h and gets cooled from 95 ^0C to 65 ^0C. At the same time 5000 kg/h of cooling water at 30 ^0C enters the heat exchanger. The flow conditions are such that overall heat transfer coefficient remains constant at 2270 $W/m^2\ K$. Determine the heat transfer area required and the effectiveness, assuming two streams are in parallel flow. Assume for the both the streams $c_p = 4.2\ kJ/kg\ K$.

b) What are the common failures in heat exchangers? Mention the properties to be considered for the selection of materials for heat exchangers. [5+5]

OR

9.a) Two horizontal panels separated by a distance of 30 mm contain air at atmospheric pressure. The temperatures of lower and upper panels are 55 ^{0}C and 20.6 ^{0}C respectively. Calculate the free convection heat transfer per m^2 of the panel surface.

b) What is fouling? What is the consideration of fouling? What are the parameters affecting fouling and how it can be prevented? [5+5]

10.a) A horizontal tube of outer diameter 20 mm is exposed to dry steam at 100 ^{0}C. The tube surface temperature is maintained at 84 ^{0}C by circulating water through it. Calculate the rate of formation of condensate per meter length of the tube.

b) A wire of 1.2 mm diameter and 200 mm length is submerged horizontally in water at 7 bar. The wire carries a current of 135 A with an applied voltage of 2.18 V. If the surface of the wire is maintained at 200 ^{0}C, calculate:
i) The heat flux, and
ii) The boiling heat transfer coefficient. [5+5]

OR

11.a) Distinguish between black body and grey body.

b) Explain the meaning of the term geometric factor in relation to heat exchange by radiation. Derive an expression for the geometric factor F_{11} for the inside surface of a black body hemispherical cavity of radius R with respect to itself. [5+5]

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