Roll No											

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING
END TERM EXAMINATION - JUN 2023

Semester : Semester VI - 2020
Course Code : MEC3003
Course Name : Sem VI - MEC3003 - Heat and Mass Transfer
Program : MEC

Date : 7-JUN-2023
Time : 9.30AM - 12.30PM
Max Marks : 100
Weightage : 50%

Instructions:
(i) Read all questions carefully and answer accordingly.
(ii) Question paper consists of 3 parts.
(iii) Scientific and non-programmable calculator are permitted.
(iv) Do not write any information on the question paper other than Roll Number.

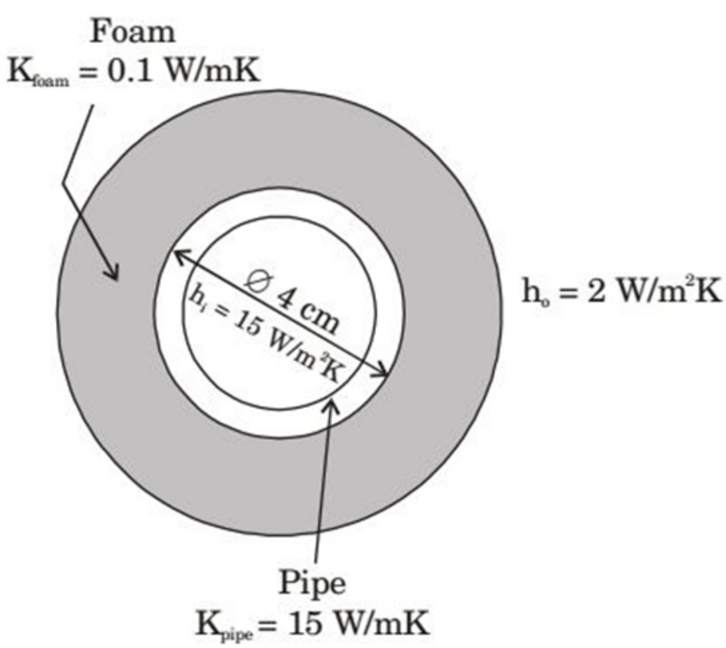
PART A

ANSWER ALL THE QUESTIONS **(10 X 3 = 30M)**

1. Define Heat Exchanger. Write down the expression for energy transfer in heat exchanger. Use standard notations.

(CO2) [Knowledge]

2. If a foam insulation is added to a 4 cm outer diameter pipe as shown in the figure, Find the critical radius of insulation (in cm).



Fig

(CO1) [Knowledge]

3. Define shape Factor with two examples and diagram. What is the maximum and minimum value of shape factor.

(CO4) [Knowledge]

4. Define NTU in heat exchangers with formula. What does NTU signifies. Also define capacity rate ratio.

(CO3) [Knowledge]

5. Explain fourier law of conduction with proper mathematical equation.

(CO3) [Comprehension]

6. A hemispherical surface 1 lies over a horizontal plane surface 2 such that convex portion of hemisphere is facing sky. What is the value of shape factor of body 1 with respect to body 2. (F_{12})

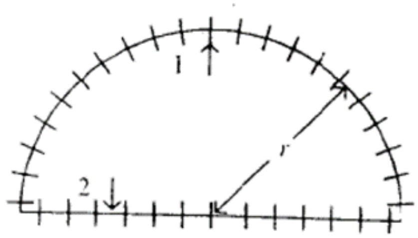


fig.

(CO1) [Knowledge]

7. Air enters a counter flow HE at 70°C and leaves at 40°C. Water enters at 30°C and leaves at 50°C,Find the LMTD in degree C. Also draw the diagram of heat exchanger with proper temperature limits.

(CO4) [Knowledge]

8. A spherical thermocouple junction of diameter 0.706 mm is to be used for the measurement of temperature of a gas stream. The convective heat transfer coefficient on bead surface is 400 W/m2K, Thermophysical properties of thermocouple material are k = 20 W/mK, c = 400 J/kgK and ρ = 8500 kg/m3. If the thermocouple initially at 30°C is placed in a hot stream of 300°C,Find the time taken by the bead to reach 298°C.

(CO4) [Knowledge]

9. Define Irradiation and Radiosity with diagram.

(CO5) [Knowledge]

10. Explain Plank's law of thermal Radiation with formula.

(CO3) [Knowledge]

PART B

ANSWER ALL THE QUESTIONS (2 X 10 = 20M)

11. Consider two surfaces (surface 1 and surface 2) with radiation heat exchange with each other. Surface temperature, area and radiosity for surface 1 is T_1 , A_1 and J_1 and T_2 , A_2 and J_2 for surace 2 respectively. Derive the surface and space resistence between both surfaces with proper diagram, Assume T_1 is greater then T_2.

(CO4) [Comprehension]

12. With neat and clean diagram, explain Parallel flow heat exchanger, counter flow heat exchanger and Regenerative type heat exchanger. What is limiting conditions for parallel flow and counter flow heat exchanger. Also draw temperature profile with proper temperature limits.

(CO3) [Comprehension]

PART C

ANSWER ALL THE QUESTIONS **(5 X 10 = 50M)**

13. a. Radiative heat transfer is intercepted between the inner surfaces of two very large isothermal parallel metal plates. While the upper plate (designated as plate 1) is a black surface and is the warmer one being maintained at 727°C, the lower plate (plate 2) is a diffuse and gray surface with an emissivity of 0.7 and is kept at 227°C. Assume that the surfaces are sufficiently large to form a two-surface enclosure and steady-state conditions to exist. Stefan-Boltzmann constant is given as 5.67 × 10^{-8} W/m^2-K^4. Find IRRIADIATION on plate 1.
b. If plate 1 is also a diffuse and Gray surface with an emissivity value of 0.8, Find the net radiation heat exchange (in kW/m^2) between plate 1 and plate 2.

(CO3) [Application]

14. a) A solid cylinder (surface 2) is located at the centre of a hollow sphere (surface 1). The diameter of the sphere is 1 m, while the cylinder has a diameter and length of 0.5 m each.Find the shape factor of body 1 with respect to itself F{11}
Draw the diagram of surface 1 and surface 2 to solve the problem.
b) A solid sphere 1 of radius 'r' is placed inside a hollow, closed hemispherical surface 2 of radius '4r' as shown in figure B. Find the shape factor F{21}

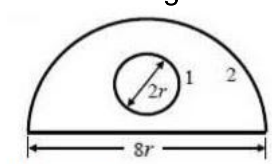


Figure-B

(CO1) [Application]

15. a) Determine the radiation heat exchange (W/m^2) between two large parallel steel plates of emissivities 0.8 and 0.5 respectively.
b) Determine the radiant heat exchange (W/m^2) between two large parallel steel plates of emissivities 0.8 and 0.5 held at temperatures of 1000 K and 500 K respectively, if a thin copper plate of emissivity 0.1 is placed as a radiation shield between the two plates.
Assume area of all plates to be 1 m^2.

(CO2) [Application]

16. a) Steam in the condenser of a thermal power plant is to be condensed at a temperature of 30°C with cooling water which enters the tubes of the condenser at 14°C and exits at 22°C. The total surface area of the tubes is 50 m^2, and the overall heat transfer coefficient is 2000 W/ m^2. Find the heat transfer (in MW) to the condenser.Also draw temperature profile of heat exchanger with temperature limits.
b) In a parallel flow heat exchanger operating under steady state, the heat capacity rates (product of specific heat at constant pressure and mass flow rate) of the hot and cold fluid are equal. The hot fluid, flowing at 1 kg/s with cp = 4 kJ/kgK, enters the heat exchanger at 102°C while the cold fluid has an inlet temperature of 15°C. The overall heat transfer coefficient for the heat exchanger is estimated to be 1 kW/m^2-K and the corresponding heat transfer surface area is 5 m^2. Neglect heat transfer between the heat exchanger and the ambient. The heat exchanger is characterized by the following relation: 2ε = 1 – exp(–2NTU). Find the exit temperature (in °C) for the cold fluid.

(CO4) [Application]

17. Consider a parallel-flow heat exchanger with area Ap and a counter-flow heat exchanger with area Ac. In both the heat exchangers, the hot stream flowing at 1 kg/s cools from 80°C to 50°C. For the cold stream in both the heat exchangers, the flow rate and the inlet temperature are 2 kg/s and 10°C, respectively. The hot and cold streams in both the heat exchangers are of the same fluid. Also, both the heat exchangers have the same overall heat transfer coefficient. Find the ratio Ac /Ap.
Also draw temperature profile for both heat exchangers with temperature limits.

(CO4) [Application]