P P SAVANI UNIVERSITY

Fifth Semester of B. Tech. Examination

December 2021

SECH3010 Heat Transfer Operations

2.12.2021, Thursday **Time: 9:00 a.m. To 11:30 a.m.** **Maximum Marks: 60**

Instructions:

1. The question paper comprises of two sections.
2. Section I and II must be attempted in separate answer sheets.
3. Make suitable assumptions and draw neat figures wherever required.
4. Use of scientific calculator is allowed.

SECTION – I

Q - 1	Answer any five of the Following	[05]
(i)	What is the physical significance of Reynolds number.	
(ii)	In forced convection, heat transfer depends on which dimensional numbers.	
(iii)	What is the SI unit of fouling factor.	
(iv)	List the different types of fins used in fin type heat exchanger.	
(v)	What are the different modes of heat transfer.	
(vi)	What is the effect of impurities on thermal conductivity of metal.	
(vii)	Maximum heat transfer rate is obtained in: (a)laminar flow or (b)turbulent flow.	
Q - 2 (a)	Derive the expression for heat conduction in a hollow spherical vessel.	[05]
Q - 2 (b)	Consider a 3-m-high, 5-m-wide, and 0.3-m-thick wall whose thermal conductivity is k =0.9 W/m · °C. On a certain day, the temperatures of the inner and the outer surfaces of the wall are measured to be 16°C and 2°C, respectively. Determine the rate of heat loss through the wall on that day.	[05]
	OR	
Q - 2 (a)	Drive the steady state heat transfer equation for composite wall.	[05]
Q - 2 (b)	A steam pipe having inside diameter of 150 mm and outside diameter of 160 mm, carries steam. The pipeline is lagging with layer of heat insulating material having K is 0.08 W/m.K of thickness 100 mm. The temperature drops from 119.8 °C to 40 °C across the insulating surface. Determine the rate of heat loss per 1 m length of pipe line.	[05]
Q - 3 (a)	Define natural and forced convection and give practical situations where convection mechanism is observed.	[05]
Q - 3 (b)	Define heat transfer coefficient and discuss about various factor affecting it.	[05]
	OR	
Q - 3 (b)	Define and give physical significance of: Nu, Gr, Pr and Re numbers.	[05]
Q - 3 (b)	Discuss about Heat and Momentum transfer analogies.	[05]
Q - 4	Attempt anyone.	[05]
(i)	Define Critical radius of insulation and derive the expression for critical radius of insulated pipe.	
(ii)	What are the desirable characteristics of Insulating materials, give name of few insulating materials.	

SECTION – II

Q - 1	Answer the Following:	[05]
(i)	Film wise condensation	
(ii)	Heat capacity	
(iii)	Fins	
(iv)	Plate type heat exchanger	
(v)	LMTD	
Q - 2 (a)	Drive LMTD for parallel flow heat exchanger.	[05]

Q - 2 (b) A 2-shell passes and 4-tube passes heat exchanger is used to heat glycerin from 20°C to 50°C by hot water, which enters the thin-walled 2-cm-diameter tubes at 80°C and leaves at 40°C. The total length of the tubes in the heat exchanger is 60 m. The convection heat transfer coefficient is 25 $W/m^2 \cdot °C$ on the glycerin (shell) side and 160 $W/m^2 \cdot °C$ on the water (tube) side. Determine the rate of heat transfer in the heat exchanger (*a*) before any fouling occurs and (*b*) after fouling with a fouling factor of 0.0006 $m^2 \cdot °C/W$ occurs on the outer surfaces of the tubes. [05]

OR

Q - 2 (a) Sketch 1-2 shell & tube type heat exchangers with labels. [05]

Q - 2 (b) Discuss relation between effectiveness & NTU for counter flow heat exchangers. [05]

Q - 3 (a) Derive expression for radiant heat exchange between two finite black surfaces by radiation. [05]

Q - 3 (b) Consider a 20-cm-diameter spherical ball at 800 K suspended in air. Assuming the ball closely approximates a blackbody, determine (*a*) the total blackbody emissive power and (*b*) the total amount of radiation emitted by the ball in 5 min. [05]

OR

Q - 3 (a) Discuss the method of forward feeding multiple-effect evaporation system. [05]

Q - 3 (b) Explain the construction with a neat sketch of standard vertical tube evaporator. [05]

Q - 4 Attempt any one [05]

(i) Discuss boiling curve with regimes of pool boiling.

(ii) Difference between pool boiling & forced convection boiling.

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SECTION – I

Q - 1 Answer the Following: **[05]**

- **(i)** Radiosity
- **(ii)** Nusselt number
- **(iii)** Boiling point elevation
- **(iv)** Prandtl number
- **(v)** Baffles

Q - 2 (a) Derive 1-D steady state heat conduction for hollow cylinder with uniform thermal conductivity. **[05]**

Q - 2 (b) Difference between steady & unsteady heat conduction. Explain with two examples. **[05]**

OR

Q - 2 (a) Consider a 3-m-high, 5-m-wide, and 0.3-m-thick wall whose thermal conductivity is k =0.9 W/m · °C. On a certain day, the temperatures of the inner and the outer surfaces of the wall are measured to be 16°C and 2°C, respectively. Determine the rate of heat loss through the wall on that day. **[05]**

Q - 2 (b) Drive the steady state heat transfer equation for composite wall. **[05]**

Q - 3 (a) Explain the physical significance of Nu, Gr, Pr and Re number. **[05]**

Q - 3 (b) What do you mean by natural convection? Give example of heat transfer by natural convection. **[05]**

OR

Q - 3 (a) Engine oil at 60°C flows over the upper surface of a 5-m-long flat plate whose temperature is 20°C with a velocity of 2 m/s. Determine the rate of heat transfer per unit width of the entire plate. **[05]**
Given data:
Density= 876 kg/m^3
Pr = 2870
k =0.144 W/m. °C
Velocity = 242 ×10^{-6} m^2/s.

Q - 3 (b) Discuss the various factors affecting convective heat transfer coefficient with examples. **[05]**

Q - 4 Attempt any one **[05]**

(i) Consider a 0.8-m-high and 1.5-m-wide glass window with a thickness of 8 mm and a thermal conductivity of k = 0.78 W/m · °C. Determine the steady rate of heat transfer through this glass window and the temperature of its inner surface for a day during which the room is maintained at 20°C while the temperature of the outdoors is -10°C (negative). Take the heat transfer coefficients on the inner and outer surfaces of the window to be h_1 = 10 W/m^2 · °C and h_2 = 40 W/m^2 · °C, which includes the effects of radiation.

(ii) What is forced convection? Is convection caused by winds forced or natural convection, give reason?

SECTION – II

Q - 1	Answer any five of the following	[05]
(i)	Define Grey body.	
(ii)	Write down Kirchoff `s law.	
(iii)	What is Subcooled boiling.	
(iv)	Why baffles are used in heat exchangers.	
(v)	What is the reason behind operating an evaporator in multiple effect.	
(vi)	What is a 1-4 shell & tube heat exchanger.	
(vii)	In shell and tube heat exchanger tube pitch is defined as.	
Q - 2 (a)	Discuss boiling curve with regimes of pool boiling.	[05]
Q - 2 (b)	Derive expression for radiant heat exchange between two finite black surfaces by radiation.	[05]
	OR	
Q - 2 (a)	Difference between nucleate & film boiling with neat sketch.	[05]
Q - 2 (b)	Consider a 20-cm-diameter spherical ball at 800 K suspended in air. Assuming the ball closely approximates a blackbody, determine (*a*) the total black body emissive power and (*b*) the total amount of radiation emitted by the ball in 5 min.	[05]
Q - 3 (a)	Define LMTD and Drive LMTD equation for counter flow heat exchangers.	[05]
Q - 3 (b)	Define the following terms: (i) evaporation (ii) boiling point elevation (iii) capacity of an evaporator and (iv) Economy of an evaporator.	[05]
	OR	
Q - 3 (a)	Discuss Relation between effectiveness & NTU for counter flow heat exchangers.	[05]
Q - 3 (b)	Draw a neat sketch of long tube evaporator and explain briefly its construction and working.	[05]
Q - 4	Attempt any one	[05]
(i)	Hot oil at a rate of 1.2 kg/s [Cp = 2083 J/(kg·K)] flows through a double pipe heat exchanger. It enters at 633 K and leaves at 573 K. The cold fluid enters at 303 K and leaves at 400 K. If the overall heat transfer coefficient is 500 W/ (m^2·K), calculate the heat transfer area for (i) Parallel flow and (ii) Counter current flow.	
(ii)	An evaporator is operating at atmospheric pressure. It is desired to concentrate the feed from 5 % to 20 % solute (by weight) at a rate of 5000 kg/h. Dry saturated steam at a pressure corresponding to saturation temperature of 399 K (126 °C) is used. The feed is at 298 K (25 °C) and boiling point rise (elevation) i.e. B.P.E is 5 K. Overall heat transfer coefficient is 2350 W/m^2 K. Calculate economy of evaporator and area of heat transfer to be provided. **Data:** Treating solution as pure water and neglecting B.P.R. Latent heat of condensation of steam at 399 K = 2185 kJ/Kg. Latent heat of vaporization of water at 101.325 kPa and 373 K= 2257 kJ/kg, Specific heat of feed = 2185 kJ/kg.	