T. E. V - Sem. Chemical.

Heat Transfer (1) Operations - I

24/11/15

(26) TE/V/CHEM/CBGS/HTO-I

Q.P. Code : 5624

(3 Hours) [Total Marks : 80

N.B: (1) Question No. 1 is compulsory
(2) Attend any three of the remaining five.
(3) Make suitable assumptions if necessary. State them clearly.
(4) Each question carries equal marks.

1. (a) 1.2kg of liquid water initially at 15°C is to be heated to 95°C in a teapot equipped with a 1200 Watt electric heating element inside. The teapot is 0.5kg and has an average specific heat of 0.7 KJ/kg°C. Taking the specific heat of water to be 4.18kJ/kg°C and disregarding any heat loss from the teapot, determine how long it will take the water to be heated. 5

(b) State assumption made in Nusselt's theory of condensation. 5

(c) What is fin efficiency and what is fin effectiveness ? 5

(d) A person is found dead at 5pm in a room whose temperature is 20°C. The temperature of the body is measured to be 25°C when found and the heat transfer coefficient is estimated to be h = 8 W/m²°C. Modelling the body as a 30cm diameter, 1.70 m long cylinder, estimate the time of death of that person. 5

2. (a) A composite furnace wall consists of 225mm of fire brick, 115mm of insulating brick and 115mm of building brick. The individual heat transfer coefficient at the inside and outside of the wall are 60W/m²C and 7 W/m²°C respectively. The temperature of gas within the furnace is 1300°C. The ambient air temperature outside the furnace is 40°C. The maximum temperature of insulating brick should not exceed 1015°C. 10

k of firebrick = 1.66 W/m°C
k of insulating brick = 0.32 W/m°C
k building block = 0.69 W/m°C

Calculate : (i) The rate of heat transfer per unit area.
(ii) Interface temperature between fire brick and insulating brick.

(b) Derive formula to calculate critical thickness of insulation for a cylinder. Also write about optimum thickness of insulation. 10

3. (a) An aluminium rod 30mm in diameter and 150mm long protrudes from a wall which is maintained at 275°C into the environment maintained at 20°C. Estimate the heat loss by rod assuming that rod end is insulated. also find fin efficiency and temperature at the end of fin. 10

Data k aluminium = 210 W/m K

h between rod surface and environment = 17 W/m² K

(b) One hundred tubes of 12mm in diameter are arranged in a square array and are exposed to steam at atmospheric pressure. Calculate the mass of steam condensed per unit length of tube if tube wall temperature is maintained at 98°C. 10

Properties of water film at mean temperature of 99°C are, $\rho = 960 kg/m^3$, $\mu = 282 \times 10^{-6}$ kg/m-s k = 0.68 W/m K, Ts = 100°C, $\lambda = 2255$ kJ/kg.

4. (a) Air at 1 atm pressure and 35°C flows across a 50mm diameter cylinder at a velocity of 50m/sec. The cylinder surface is maintained at a temperature of 50°C. 10

Estimate the heat loss per unit length of cylinder, use correlation.

$N_{Nu} = 0.0266(NRe)^{0.805}(Npr)^{1/3}$

Data: Physical properties of air at mean film temperature.

$\mu = 2.14 \times 10^{-5} \frac{kg}{m.sec}$, $\rho = 0.966 \frac{kg}{m^3}$, $k = 0.31 \frac{W}{m°C}$, Npr = 0.695.

(b) A steam pipe of 60cm long and 60mm i.d. carries steam at a pressure of $800 \times 10^3 \frac{N}{m^2}$ (Ts = 170°c) 10

Surrounding air temperature is 17°C

Using following data, calculate the rate of heat loss.

(i) Emissivity $\epsilon = 0.85$

(ii) Stephen Boltzmann constant $(\sigma) = 5.67 \times 10^{-8} \frac{W}{m^2K^4}$

(iii) Natural convertive coefficient $h = 1.65(\Delta T)^{0.25}$.

(3)

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5. A double pipe heat exchanger is used to heat the fuel oil from 10°C to 20°C using a hot water available which is at 71°C. The water flows through copper tube (OD = 2.13cm and ID = 1.86cm) with a velocity of 0.75m/s. The oil passes through annulus, formed by inner copper tube and outer steel pipe (OD = 3.34cm and ID = 3cm). Fuel oil hows at the rate of 3960 kg/hr. Design the heat exchanger for above requirement. Use correlation for calculation of film transfer coefficients of both sides as 20

$$Nu = 0.023\ (NRe)^{0.8}\ (Npr)^{0.3}$$

Data : Take the following properties of water and oil.

Property	Water	Oil
ρ (kg/m³)	982	854
Cp (kJ/kg°C)	4.187	1.884
k (W.m°C)	0.657	0.138
η (m²/s)	4.18 × 10-7	7.43 × 10-6

fouling factor $f_{water} = 0.0004 \dfrac{m^{2\circ}C}{W}$, $f_{oil} = 0.0009 \dfrac{m^{2\circ}C}{W}$

6. (a) Derive for parallel how heat exchanger 10

$$\in = \frac{1 - \exp\left[NTU(1+C_r)\right]}{1+C_r}$$

$\in$ = effectiveness, Cr = Capacity ratio.

(b) State and explain briefly, the laws of radiations. 10
