INSTITUTE OF CHEMICAL TECHNOLOGY MUMBAI

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THIRD YEAR .B.CHEM.ENGG.(SEM V) EXAMINATION NOVEMBER 2019

CET 1102: HEAT TRANSFER

DATE : NOVEMBER 11, 2019 **TIME : 03:00 PM - 06:00 PM**
DAY : MONDAY **MARKS : 50**

Note Solve any Five questions
The formulae are attached with the question paper.
Use well-labeled figures/schematics for explanation/problem solutions.
Make suitable assumptions wherever necessary and state them clearly

Q 1. With suitable example design detailed protocol for design of shell and tube heat exchanger for cooling hot oil by water. It is mandatory to start from the requirement of data available (10)

Q2.

i. 150 kg of water is to be heated in a steam-jacketed vessel from 25°C to 80°C. Steam is condensing at 120°C, and the heat transfer area is 0.25 m^2. The heat transfer coefficient for condensation of steam and heating of water by convection are 1000 W/m^2 and 500 $W/m^2°C$ respectively. Write appropriate unsteady balance equations and find the time required for the heating water. Assume that the specific heat of water in the temperature range of interest is 4.18×10^3 J/kg °C (6)

ii. Obtain an equation to determine the temperature profile across the rod. Use this equation to determine the heat transfer through the rod when rod is insulated at other ends. (4)

Q3.

i. A carbon steel sphere, 0.3 m in diameter and at 800 K, cools down by radioactive heat loss to ambient at 30°C. If other modes of heat loss are neglected, and if the ball and the ambient are assumed to be black, calculate the time required for the ball to cool down to 70°C. The density and specific heat of the carbon steel are 7801 $kg/m^3$and 0.473 kJ/kg°C, respectively. (5)

ii. Discuss the pool boiling phenomenon and suggest its significance. List the various heat transfer equipment with heat transfer occurs via pool boiling. (5)

Q4.

i. Counter current flow double pipe heat exchanger is used to heat water flowing at 1 kg/s from 40°C to 80°C. Oil is used for heating and its temperature changes from 100°C to 70°C. The overall heat transfer coefficient is 300 $W/(m^2°C)$. If it is replaced by a 1.2 shell and tube heat exchanger with counter current flow configuration with water flowing in shell and oil

flowing in the tube, what is the excess area required with respect to double pipe heat exchanger? The correction factor, F_t for LMTD based on the above double pipe heat exchanger is 0.5. The heat transfer coefficient remains unchanged, and the same inlet and outlet conditions are maintained. Cp_{water} is 4180 J/kg°C, Cp_{oil} is 2000 J/kg°C (5)

ii. Compare a. Kern b. Bell Delaware c. Flow stream analysis method (5)

Q5.

i. A Shell and tube steam condenser is to be constructed of 2.5 com O.D. 2.2 cm I.D., single pass horizontal tubes with steam condensing at 54°C on the outside of the tubes. The cooling water enters at 20°C and leaves at 36°C at a flow rate of 1 Kg/s. The heat transfer coefficient for the condensation of the steam is 7900 W/(m^2°C). Calculate the tube length. If the latent heat of condensation is 2454 kJ/kg, calculate the condensation rate per tube. The heat transfer coefficient for turbulent flow in a pipe may be determined by

$Nu = 0.023\ Re^{0.8}\ Pr^{0.4}$ (5)

ii. Determine/Derive the local and average heat transfer coefficient equation for a vapor condensing on a vertical wall. (5)

Q6.

i. A pipe is 20 mm ID and 30 OD is insulated with 35 mm thick insulation. Temperature of the bare pipe is 200°C. The thermal conductivity of the insulating material is 0.15 W/m°C and the convective heat transfer coefficient of outside is 3 W/m^2°C. The surface temperature is 30°C. The heat transfer resistance of the metal can be neglected.

a) Comment with reasoning about the heat transfer rate with and without insulation

b) If the same insulating material is used, what is the minimum thickness above which there is a reduction n heat loss as compared to the bare pipe?

c) For optimum design, what conductivity of insulating material do you suggest for the conditions given in the problem?

(6)

ii. Classify different evaporators and sketch at least 6 evaporators (4)

Formulae

Double pipe Heat Exchanger

Dittus Boelter Equation

$$\frac{h_i d}{k} = 0.023\left(\frac{du\rho}{\mu}\right)^{0.8}\left(\frac{C_p\mu}{k}\right)^{n}$$ n = 0.4 for heating n = 0.3 for cooling

$$D_e = \frac{4\left(p^2 - \frac{\pi d_o^2}{4}\right)}{\pi d_o}$$ For square

$$D_e = \frac{4\left[(0.5p)(0.86p) - \left(\frac{\pi d_o^2}{8}\right)\right]}{\frac{\pi d_o}{2}}$$ For Triangular Pitch