T.E. Sem-V (CBSGS) chemical- HTO-I 28/11/16
Heat Transfer Operations-I

QP Code:573700

(Revised Course)
(3 Hours)

Total Marks: 80

N.B.: (1) Question No.1 is compulsory.
(2) Attempt any **Three** out of remaining questions.
(3) Assume any suitable data if necessary and indicate it clearly.
(4) Draw neat sketches wherever required.
(5) Answer to the sub-questions of an individual question should be grouped and written together i.e. one below the other.

1. Solve all subquestions:
   (a) Explain the term emissive power and emissivity in radiation. (05)
   (b) Define fin effectiveness and fin efficiency in heat transfer through extended surface. (05)
   (c) State (only) assumptions for Nusselt theory for condensation. (05)
   (d) Wilson's plot. (05)

2. (a) A furnace is constructed with a 229 mm thick layer of fire brick,115 mm thick Layer of insulating brick and followed by a 229 mm thick layer of building brick. The inside temperature of the furnace is 1223 K (950°C) and the outside temperature is 323 K (45°C).The thermal conductivities of fire brick, insulating brick and building Brick are 6.05, 0.581 and 2.33 W/m.K. Find the heat loss per unit area and the temperature at the interfaces. (10)

   (b) A cylindrical tube of length L having inside radius r_1 and outside radius r_2 is lagged by insulating material with r_3 as the outer radius of insulation. Thermal conductivity of the wall material is k_1 and thermal conductivity of Insulation is k_2. T_1,T',T_2 are the temperatures at inside the tube,at the interface between the tube and insulation and at the outer edge of insulation respectively. $T_1 > T_2$. Derive an expression for rate of heat flow. (10)

3. (a) For heat transfer by force convection show that Nusselt number is function of Reynolds number and prandti number by dimensional analysis. (10)
   (b)Derive design equation for heat exchanger "$Q = U.A.\Delta T_{lm}$". (10)

4. It is desired to heat 4450 Kg/hr of cold benzene from 300K (27°C) to 322K(49 °C) using hot toulene which is cooled from 344K (71°C) to 311K (38°C).The specific gravities of benzene and toulene are 0.88 and 0.87 respectively.A fouling factor of 1.60 x 10^{-4} (m^2K/W) should be provided for each stream.

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Data:

Inner diameter of inner pipe = 35 mm
Outer diameter of inner pipe = 42 mm
Inner diameter of outer pipe = 52.5 mm
For a 31.75mm IPS standard pipe there is 0.1326 m^2 of external surface per m length.
Physical properties of two fluids at mean temperature are as given below:

Property	Benzene	Toulene
Specific heat	1.779 KJ/Kg.K	1.842 KJ/Kg.K
Thermal conductivity	0.147 W/m.K	0.157 W/m.K
Viscosity	4.09×10^{-4} Kg/m.s	5.0×10^{-4} Kg/m.s

Neglect metal wall resistance. Benzene flows through the inner pipe in a counter current fashion to toulene. (20)

5. (a) A large vertical plate 4 m high is maintained at a temperatureof 333 K (60°C) and exposed to air at 283 K (10°C). Calculate the rate of heat transfer if the plate is 7m wide.
Data: The properties of air at the film temperature of 308K are:

β	3.25×10^{-3} K^{-1}
N_{pr}	0.7
Thermal conductivity	0.02685 W/m.K
Kinametic Viscosity	16.5×10^{-6} m^2/sec

(10)

(b) A vertical plate,30 by 30 cm, is exposed to steam at atmospheric pressure.The plate is at 371K(98°C).Calculate the average/mean heat transfer coefficient,the heat transfer rate and the mass of steam condensed per hour.
Data: The properties of the condensate at the film temperature are:

Density	960 Kg/m^3
λ	2255 KJ/Kg
Thermal conductivity	0.68 W/m.K
Viscosity	2.82×10^{-4} Kg/m.s

Saturation temperature of steam=373K (100°C).Assume that the flow of condensate is laminar. (10)

6. Write short note on (any four) (20)
(a) Boiling regimes in pool boiling
(b) Unsteady state heat transfer with negligible internal resistance
(c) Extended surface for heat exchanger
(d) Significance of Biot Number and Fourier Number.
(e) Effectiveness-NTU method of heat exchanger analysis.

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