(Following Paper ID and Roll No. to be filled in your Answer Books)

Paper ID : 151410 **Roll No.** | | | | | | | | | | |

B.TECH.

Theory Examination (Semester-IV) 2015-16

HEAT TRANSFER

Time : 3 Hours ***Max. Marks : 100***

Section-A

1. Attempt all parts of the following : (2×10=20)

(a) Explain Kirchhoff's law

(b) Define Black body & Gray body

(c) Define Natural and forced convection

(d) Define Capacity and economy of evaporator

(e) Explain Dropwise and Filmwise condensation

(f) Explain physical significance of Nusselt No, Prandtle No, Grashoff No, Stantan No.

(g) Discuss in brief about molten metal.

(h) What do you understand by overall heat transfer coefficient?

(i) What are fins? Write its application?

(j) Explain the fouling factor.

Section-B

2. Attempt five parts of the following. (5×10=50)

(a) What is optimum thickness of insulation? Derive the critical thickness of insulation of Cylinder.

(b) An industrial wall is constructed of 20cm thick fireclay, k=1W/m°C. This is covered on outer surface with a 3 cm layer of insulating material, k=0.075 W/m°C. The innermost surface is at 940°C & the outermost at 40°C. Calculate the steady rate of heat transfer through the wall in w/m^2 & the temperature of the interface between the fireclay & the insulating material.

(c) The outer surface temperature of a pipe (radius = 0.1 m) is 400 K. The pipe is losing heat to atmosphere, which is at 300K. The film HTC is 10 W/m^2K. To reduce the rate of heat loss, the pipe is insulated by a 50 mm thick layer of asbestos, k = 0.5 W/mK. Calculate the percentage reduction in rate of heat loss.

(d) A horizontal steam pipe 20m long, 50mm internal diameter, 60mm outside diameter losses 3.5kw heat to the surrounding at 310k. The pipe carries steam at 500k given that the convective heat transfer coefficient $hc=1.65(\Delta T)^{-0.25}$ W/m^2 k and the Stefan Boltzmann constant=5.67*10-8 W/m^2 k^{-4}. Find the emissivity of the bare surface of the pipe.

(e) Oil at 120°C is used to heat water at 30°C in a 1-1 con-current shell and tube heat exchanger. The available heat exchanger area is A_1. The exit temperature of the oil and the water streams are 90°C and 60°C respectively. The con-current heat exchanger is replaced by 1-1 counter current heat exchanger having heat exchange area A_2. If the exit temperature and the overall heat transfer coefficient are same. What is the ratio of A_1 to A_2?

(f) A double pipe heat exchanger is to be designed to heat 4 kg/s of a cold feed from 20 to 40°C using a hot stream available at 160°C and a flow rate of 1 kg/s. The two streams have equal specific heat capacities and the overall heat transfer coefficient of the heat exchanger is 640 W/m^2 k. What is the ratio of heattransfer area for con-current and counter current modes of operations?

(g) Explain hydrodynamic boundary layer & thermal boundary layer.

(h) Prove by dimensional analysis that Nu=f (Re, Gr)

Section-C

Attempt two parts of the following. (2×15=50)

3. (i) In a concurrent heat exchanger, an oil stream is cooled from 450K to 410K by water inlet & outlet temp^s of 300K & 350K respectively. The exchanger consists of a number of tubes of 1m length each. It is now desired to cool the oil to 390K (instead of 410K) while

maintaining the flow rate of oil, flow rate of water, inlet temps of oil & water & number of tubes at the same values as before. Calculate the length of each tube required for this purpose. Assume the physical properties remain unchanged.

(ii) An aqueous solution of a solute is concentrated from 5% to 20% (mass basis) in a single effect short tube evaporator .The feed enters the evaporator at a rate of 10 kg/s & at a temp of 300K steam is available at a saturation pressure of 1.3 bar. The pressure in the vapor space of the evaporator is 0.13 bar & the corresponding saturation temperature of steam is 320K. If the overall HTC is 5000w/m^{2}K. Calculate steam economy & heat transfer surface area.

Data:

	Enthalpy (KJ/kg)	**Heat of vaporization (KJ/kg)**
Saturated steam (1.3 bar, 380K)	------------	2000
Saturate steam (0.13bar, 320K)	2200	------------
Feed (5%, 325 K)	80	------------
Concentrated liquor (20%, 325K)	400	------------

BPR is 5K

4. (i) Saturated steam at 6.9×10^4 Pa pressure and 90°C saturation temperature condenses on a vertical pipe of 0.025m OD and 0.3m length. The average condensing HTC on the tube is 12000 W/m^2K.

Data:

Outside surface temperature of the pipe = 86°C

Enthalpy of saturated steam = 2659kJ/kg

Enthalpy of condensate = 375kJ/kg

Viscosity of condensate at the film temperature $=3.24\times10^{-4}$ pa s

Assume the flow of the condensate is laminar.

Calculate the rate of steam condensation.

Check whether the flow is laminar.

(ii) Explain capacity & economy of evaporator. Show by sketch, the various methods of feeding arrangement in triple effect evaporators. Discuss their relative merits & demerits.

5. (i) A horizontal steam pipe 220m long, 50mm ID, 60mm OD loses 13.5kW heat to the surroundings at 310K. The pipe carries steam at 500K. Given that the convective heat transfer coefficient $h_c = 1.65 (\Delta T)^{0.25}$ W/m^2K & Stefan - Boltzmann constant, $\sigma = 5.67\times10^{-8}$ $W/m^2 K^4$. Find the emissivity of the bare surface of the pipe.

(ii) In a 1- 1 counter flow shell & tube heat exchanger,a process stream (Cp=4.2kJ/kgK) is cooled from 450K to 350K Using water (Cp=4.5 kJ/kgK) at 300K. The process stream flows on the shell sides at a rate of 1 kg/s & the water on the tube side at a rate of 5 kg/s. If HTC on the shell & tube sides are 1500 W/m^2K & 1500 W/m^2K respectively.

Determine:-

I. The required heat transfer area

II. By what factor will the required area change if the flow is co-current?