5th semester B.Tech degree Examination
(2013 scheme)
13.504 PRINCIPLES OF HEAT TRANSFER IN BIOPROCESSES (B)

Time: 3hours Max.marks: 100

Part A
Answer all questions

1) Define the term Critical thickness of insulation'. Give the same for cylinder and sphere?

2) What are the different boundary conditions applied in heat transfer problems ?

3) Write the physical significance of Biot number. A metal wire of 0.02m dia and thermal conductivity 22 W/m K is exposed to a fluid stream with a convective heat transfer coeffient 111W/m K. find out Biot number ?

4) What is lumped capacity analysis? Write the assumptions involved in it.

5) With neat sketch shell and tube heat exchanger and label the different parts.

6) Explain hydrodynamic boundary layer and thermal boundary layer?

7) Define the term "overall heat transfer coefficient

8) Distinguish between filmwise and dropwise condensation?

9) Why counter flow heat exchanger more effective than a parallel flow heat exchanger

10) Make a list of examples of industrial evaporation operation **(10x 2=20)**

PART B

Answer one full question from each module

Module 1

11)a) Show that in a long cylinder of radius R with uniformly distributed heat sources, the temperature distribution is prescribed by the relation

$t - tw / t\,max - tw = 1 - (r/R)^2$

Where tw is the temperature at the outer surface of the cylinder and tmax is the temperature along the cylinder axis. 20

OR

12) A refractory brick wall is used an thermal shield in an equipment. The thermal conductivity of this material varies with temperature as

K = 0.045 [1+ 0.0041 T] expressed in K cal/ hr/ m°K . the thickness of the wall is 90cm. the hot side temperature is 350°c and cold surface temperature is to be maintained at 40°c. It is desired to locate a coolant pipe at a thickness where the point temperature in the refractory is 280°c. Calculate the distance to this point from the hot surface. 20

Module 2

13) a) sketch boundry layer formation over a plate surface and inside a pipe. 6

b) It is desired to design a cross flow heat exchanger(both unmixed type) for liquid metal and air with following temperature, Thi=820°c, Tho=520°c Tci=320°c and Tco= 720°c. the flow rate of air is 100 kg/sec. and $C_{p\,c}$ =2.09 KJ/ Kg K and average flow rate of metal is 150 Kg/ sec and $C_{p\,h}$ =1.672 KJ/Kg K . The overall heat transfer coefficient is 696 W/ M^2K. find the area required for the above mentioned heat transfer heat transfer using LMTD method 14

OR

14 a) Explain different laws of radiation. 8

b) The furnace of a double walled spherical vessel used for storing liquid oxygen are covered with a layer of silver having an emissivity of 0.03. the temperature of the outer surface of the inner wall is -153◦C and the temperature of the inner surface of the outer wall is 27◦C. the sphere are 42cm and 60cm in diameter, with the space between them evacuated. Calculate the radiation heat transfer through the wall into the vessel and the rate of the evaporation of liquid oxygen if its rate of vaporization is 220 kJ/kg 12

Module.3

15) Explain what are the different boiling regimes. 20

OR

16) Derive nusslet equation with assumption ? 20

Module 4

15) A shell and tube heat exchanger must be designed to heat 2.5 Kg/s of water from 15 to 85°c. The heating is to be accomplished by passing hot engine oil, which is available at 160°c, through the shell side of the exchanger. The oil is known to provide an average

convection coefficient of 400 W/ m^2.K on the outside of the tube. Ten tubes pass through the shell. Each tube is thin walled, of diameter 25mm and makes eight passes through the shell. If the oil leaves the exchanger at 100°c, what is its flow rate? How long must the tube accomplish the desired heating?

The properties of the fluids: C_P of engine oil at 130°c = 2350 J/Kg.
for water at 50°c: C_P=4180J/ Kg K, $\mu = 548\times10^{-6}$ N.s/m^2,
k =0.643W/m, Pr= 3.56 20

OR

16) Classify different type of evaporator with neat sketch. 20

(4x20=80)