BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: IMSC **SEMESTER : IX**
BRANCH: FOOD TECHNOLOGY **SESSION : MO/2022**

SUBJECT: FT515 FOOD PROCESSING EQUIPMENT DESIGN

TIME: 3:00 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

			CO	BL
Q.1(a)	Why excess air is used in the combustion reaction? How can we calculate the percentage of excess air used in the reaction?	[2]	1	1
Q.1(b)	In the production of SO_3, 100 kmol of SO_2 and 100 kmol of O_2 are fed to a reactor. If the percentage conversion of SO_2 is 80, calculate the composition of the product stream on mole basis.	[3]	1	3
Q.1(c)	Chlorinated diphenyl is heated from 40ºC to 280ºC in an indirectly fired heater at the rate of 4000 kg/h. Calculate the heat required to be added to the fluid in the heater. The heat capacity of the fluid in this temperature range is given by $C = 0.7511+1.465\times10^{-3}\,T$, kJ/(kg.K) where T is in K.	[5]	1	3
Q.2(a)	Why log mean temperature difference (LMTD) is used in heat exchangers for calculating area required for heat transfer?	[2]	4	1
Q.2(b)	Calculate the Reynolds number using following data: Mass flow rate = 41 kg/h, Diameter = 10 mm, viscosity = 4.65 cP.	[3]	4	3
Q.2(c)	Cold fluid is flowing through the heat exchanger at a rate of 15 m^3/h. It enters the heat exchanger at 303 K and leaves at 328 K. The hot thermic fluid enters the heat exchanger at the rate of 21 m^3/h at a temperature of 388 K. Find out the area of heat transfer required assuming the flow is countercurrent and overall heat transfer coefficient be 3490 W/(m^2.K). **Data**: Density of cold fluid = 1000 kg/m^3 Density of thermic fluid = 950 kg/m^3 Specific heat of cold fluid = 4.187 kJ/(kg.K) Specific heat of thermic fluid = 2.93 kJ/(kg.K)	[5]	4	3
Q.3(a)	Write the Bernoulli equation including pump work and friction losses in the unit of J/kg form.	[2]	3	1
Q.3(b)	Calculate the net positive suction head (NPSH) of the pump in meter using following data: Vapor pressure of liquid = 20 kPa Distance between the level of liquid in the reservoir and suction line = 1.5 m Density of liquid = 800 kg/m^3 Friction in suction line = 3.5 J/kg Reservoir is open to atmosphere.	[3]	3	3
Q.3(c)	Water is to be pumped at a rate of 198 m^3/h from a pond to a tank which is placed 10 m above the pond level. The total length of pipeline is 1 km. The diameter of pipe is 500 mm. Calculate the head loss due to friction and power requirement if pump efficiency is 50%.	[5]	3	3

PTO

Q.4(a)	Write the relationship between U_i, h_i, h_o, X_w/K and R_d.	[2]	4	1
Q.4(b)	Calculate the heat transfer area of 1-2 shell and tube heat exchanger from the following data: Inlet and outlet temperature of hot fluid are 423 K and 353 K, respectively. Inlet and outlet temperature of cold fluid are 303 K and 318 K, respectively. Overall heat transfer coefficient = 4100 W/(m^2.K) Heat loss = 407 kW	[3]	4	3
Q.4(c)	Calculate the total length of double pipe heat exchanger required to cool 5500 kg/h of ethylene glycol from 358 K to 341 K using toluene as a cooling media which flows in counter current fashion. Toluene enters at 303 K and leaves at 335 K. **Data:** Outside diameter of outer pipe = 70 mm Outside diameter of inner pipe = 43 mm Wall thickness of both pipes = 3 mm Thermal conductivity of metal pipe is 46.52 W/(m.K) Ethylene glycol flows through the inner pipe.	[5]	4	3

Mean properties of two fluids are as below:

Property	Ethylene glycol	Toluene
Density (kg/m^3)	1080	840
Specific heat (kJ/(kg.K))	2.680	1.80
Thermal conductivity (W/(m.K))	0.248	0.146
Viscosity (Pa.s)	3.4×10^{-3}	4.4×10^{-4}

Q.5(a)	An evaporator is fed with 15000 kg/h of a solution containing 10% NaCl, 15% NaOH and rest water. In the operation, water is evaporated and NaCl is precipitated as crystals. The thick liquor leaving the evaporator contains 45% NaOH, 2% NaCl, and rest water. Calculate kg/h of water evaporated.	[2]	5	3
Q.5(b)	Describe the following terms: (a) boiling point rise, (b) capacity of evaporator, (c) economy of an evaporator	[3]	5	2
Q.5(c)	It is desired to concentrate 5000 kg/h of a solution of NaOH from 10% to 25% solids in a single-effect evaporator. Steam is available at 110ºC, and the vapour space is maintained at 410 mmHg. The boiling point of water corresponding to the vapour space pressure is 84ºC. The solution has a boiling point elevation of 10ºC. The enthalpies of the feed and thick liquor are 90 and 80 kcal/kg, respectively and the enthalpy of the vapour is 650 kcal/kg. The feed enters at its boiling point corresponding to the vapour space pressure. Latent heat of steam (λs) is 534 kcal/kg. Calculate the steam consumption per hour. If the available heat transfer area is 35 m^2, estimate the heat transfer coefficient.	[5]	5	3

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