Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E –IIst SEMESTER–EXAMINATION – JULY- 2012

Subject code: 1723003 Date: 10/07/2012

Subject Name: Advance Equipment Design

Time: 10:30 am – 13:00 pm Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** In a heating furnace the temperature of the hot flue gas is constant over entire volume (19.16 m^3) and is equal to 900°C. The flue gas contains combustion products CO_2, H_2O and N_2 and its total pressure is 1 atm. The partial pressures of CO_2 and H_2O are 0.13 and 0.11 atm respectively. **07**

Calculate the total emissivity of the flue gas and the radiation flux emitted by the products of combustion if the total surface enclosure is 30 m^2.

$\sigma = 0.567 \times 10^{-7}$ W/m^2 °K^4.

(b) Calculate the size of the cyclone needed for separating particles of a dry material from the air leaving a spray dryer according o the following data: **07**

Data:

Smallest size of particles = 80μm

Flow rate of air = 2000 kg/hr

Temperature = 100°C

Local resistance coefficient (dimensionless resistance coefficient of a cyclone), ζ =160

Give a neat sketch of designed equipment.

Q.2 A furnace is to be designed for a total heat duty of 12.6×106 kcal/hr. The overall efficiency is 75%. Oil fuel with calorific value 39850 KJ/kg (9519 kcal/kg) is to be fired with 25% excess air (corresponding to 17.44 kg air/ kg of fuel) and the air preheated to 200°C. Steam for atomizing the fuel is 0.3 kg / kg of oil. Furnace tubes are to be 12.5 cm O.D. on 21.6 cm centres, in a single row arrangement. The exposed tube length is 10 m. The average tube temperature in radiant section is 425°C. **14**

Design the radiant section of a furnace having a radiant section average flux of 37850 W/m2.

OR

Q.2 In a steam super heater having suggested layout of tubes (S1=S2=2do), the hot flue gas enters at 850°C. The outer surface temperature of the tubes may be assumed to be constant and equal to 600°C. **14**

Determine the coefficient of heat transfer by radiation from flue gas to the surfaces of the super heater tubes.

The emissivity of the surface of the tubes is 0.85

Tube O.D. = 55 mm

Flue gas pressure = 1 atm

Flue gas composition: CO2 = 13%, H2O = 11%, N2 = rest

S1 = Transverse pitch

S2 = longitudinal pitch

σ = 0.567 × 10-7 W/m2 °K4

Q.3 Design a horizontal extractor to treat 1000 kg of seeds/hr containing 30% oil, to recover 95% oil. Solvent lost with the seeds is 10% (of the seeds coming out). Solvent charged is 1000 kg/hr. Find the number of stages. If the contact time required is 6 min and draining time is 6 min, find out the length of the belt to be provided considering loading and unloading length. Thickness of the seed layer over the belt is 50 mm and Effective breadth of the belt is 1m. Find out the linear speed of the belt. **14**

X:	0.02	0.025	0.055	0.095	0.135	0.19	0.2075
Y:	0.02	0.07	0.09	0.125	0.173	0.235	0.27

N:	4.5	2.35	1.97	1.6	1.325	1.05	0.95
Y:	0.02	0.07	0.09	0.125	0.173	0.235	0.27

Where, N = Wt of insoluble / (Wt of oil + Wt of hexane)

X = Wt. of oil/(Wt. of oil + Wt. of hexane) in raffinate phase

Y = Wt. of oil/(Wt. of oil + Wt. of hexane) in extract phase

OR

Q.3 Roasted copper ore containing copper as $CuSO_4$, is to be extracted in a counter current extractor. The feed charge to be treated per hour comprises 10 tonnes of gangue, 1.2 tonnes of copper sulphate and 0.5 tonnes of water. The strong solution produced is to consist of 90% H_2O and 10% $CuSO_4$ by weight. The recovery of $CuSO_4$ is to be 98% of that of the ore. Pure water is to be used as the fresh solvent. After each stage one tonne of inert gangue retains 2 tonnes of water plus the copper sulphate dissolved in that water. Equilibrium is attained in each stage. How many stages are required? **14**

Q.4 **(a)** List out and explain the selection criteria for dryers. **07**

(b) What is the capacity in m^3/hr of a clarifying centrifuge operating under the following conditions? **07**

Data:
Diameter of bowl = 0.6 m
Thickness of liquid layer = 0.075 m
Depth of the bowl = 0.4 m
Speed = 1200 rpm
Specific gravity of liquid = 1.2
Specific gravity of solid = 1.6
Viscosity of liquid = 2 cP
Cut size of particles = 30μm

OR

Q.4 **(a)** Evaluate the effectiveness factor for heat sink having single row of tubes in front of refractory wall with the radiating plane parallel to the tube row. State your assumptions. Show the evaluation of α showing flux distribution on the tube circumference. **07**

(b) Sodium sulphate crystals are to be produced from an aqueous solution of sodium sulphate available at 104°C. Total weight of solution is 8600 kg and it contains 29.6% by weight of anhydrous sodium sulphate. During cooling, 4.5% of the initial water is lost by evaporation. The mother liquor contains 18.3% by weight of anhydrous sodium sulphate. Estimate the yield of crystals and the quantity of mother liquor to be recycled form the crystallizer? **07**

Data:
Molecular wt. of anhydrous sodium sulphate crystals = 142
Molecular wt. of hydrated sodium sulphate = 322

Q.5 Calculate the diameter and length of an adiabatic rotary dryer to dry 1270 kg/hr of a heat sensitive solid from an initial moisture content of 15% to a final moisture content of 0.5%, both dry basis. The solids enter at 26.7°C and must not be heated to a temperature above 51.7oC. Heating air is available at 126.7°C and a humidity of 0.01 kg of water / kg of dry air. The maximum allowable mass velocity of the air is 3420 kg/hr-m2. **14**

Data:

λ(water) at 38.8°C:	575 kcal/kg
Specific heat of solids Cps:	0.52 kcal/kgoC
Specific heat of water vapor Cpv:	0.45 kcal/kgoC
Specific heat of liquid CpL:	1 kcal/kgoC
Specific heat of humid air:	0.245 kcal/kgoC
Nt:	1.5
Inlet bulb Temp. Twb:	38.8C

OR

Q.5 A rotary drum filter with 30% submergence is to be used to filter a concentrated aqueous slurry of $CaCO_3$ containing 236 kg/m^3 of solids .The pressure drop is to be 20 in.Hg. if the filter cake contains 50% moisture (wet basis). Calculate the filter area required to filter 10 gal/min of slurry when the filter cycle time is 5 min. Assume that the temperature is 20°C. **14**

$\alpha = \alpha_0 \times (\Delta P)^{0.26}$ Where, $\alpha_0 = 8.17 \times 10^{10}$ ΔP = in N/M^2

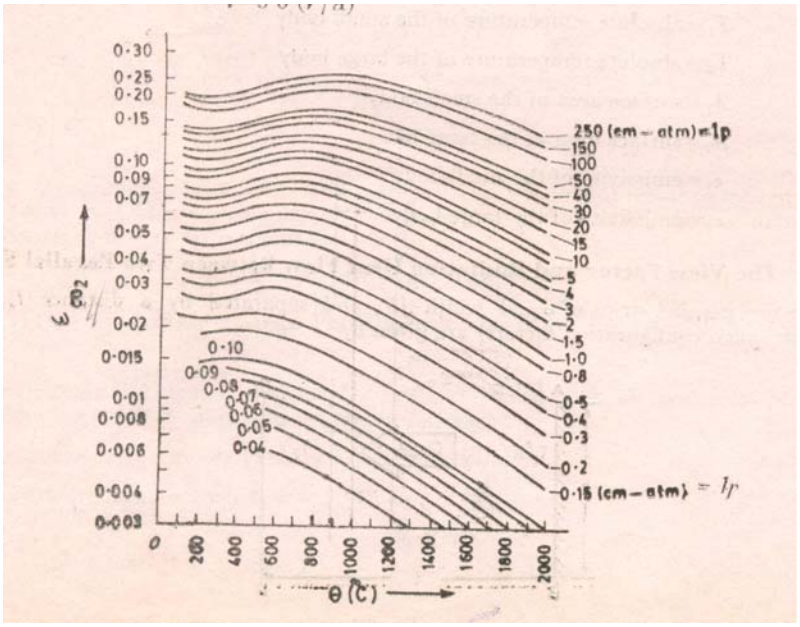

Fig. A Emissivity of Carbon-dioxide

Fig. B Emissivity of Water Vapour

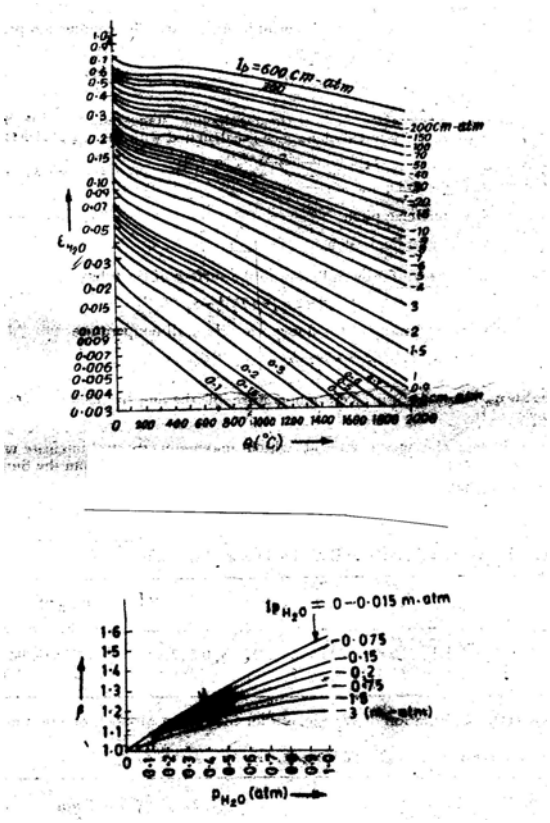

Fig. C β vs p_{H2O}

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