Seat No.: _____ *Enrolment No._____*

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. Sem. – II[nd] - Examination – June/July- 2011

Subject code: 1723003

Subject Name: Advance Equipment Design

Date:27/06/2011 **Time: 10:30 am – 01:00 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)** A furnace utilizes the combustion gas which is a mixture of CO_2, H_2O and N_2 with partial pressure of CO_2 and H_2O 0.13 atm and 0.11 atm respectively. It is assumed that the temperature of hot flue gases is constant and is 1200°C. If the volume is 19.5 m^3, calculate the total emissivity of the flue gas and the radiation flux emitted by the gases if the total surface of enclosure is 30m^2. **07**

$\sigma = 0.567 * 10^{-7}$ W/m^2 $^oK^4$

(b) Show with diagram the distribution of the radiant rate on the tube circumference for the single row of tubes in a furnace. **07**

Q.2 **(a)** Determine the diameter and all other dimensions of the cyclone separator to separate the solid dust particles of minimum diameter 15μm. The rate of flow of dust laden air is 5100 m^3/hr at 0°C and 760 mm Hg. Take the local resistance co-efficient ζ_0 = 160. **07**

Data:
Pressure drop = 7.6 mmHg
Density of dust = 1200 kg/m^3

(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

OR

(b) List out and explain the selection criteria for dryers. **07**

Q.3 A batch centrifugal filter having a bowl diameter of 750 mm and a bowl height of 450 mm is used to filter a suspension having the following properties: **14**

Data:
Liquid-Water
Temperature = 25^{o}C
Concentration of solid in feed = 60 g/L
Porosity of cake = 0.835
Density of dry solid in cake = 2000 kg/m^3
Final thickness of cake = 150 mm
Spped of centrifuge = 2000 r/min
Specific cake resistance = 1.31 *10^{10} m/kg
Filter medium resistance = 8.53*10^{10} m^{-1}

The final cake is washed with water under such conditions that the radius of the inner surface of liquid is 200 mm. Assuming that the rate of flow of wash water equals the final rate of flow of filtrate, what is the rate of washing in m^3/hr?

OR

Q.3 An aqueous slurry containing 236 kg/m^3 of solids is to be filtered in a press having a total area of 8 m^2 and operated at a constant pressure drop of 2 atm. The frames are 36 mm thick. Assume that the filter medium resistance is negligible and specific cake resistance is given by the following equation: **14**

$\alpha = \alpha_0(\Delta P)^S$ where ΔP is in N/m^2.

Where,
α_0 =8.17*10^{10} N/m^2
S = 0.26

Data:
Viscosity of liquid = 0.8 cP
Density of liquid = 1000 kg/m^3
The wet cake contains 50% moisture (wet basis).
Density of dry cake = 1250 kg/m^3
Time for assembling and de-assembling the filter press = 20 mins
Calculate the filtration time required and the volume of filtrate obtained in one cycle?

Q.4 A tray dryer with 12 trays is available. Area of one tray is 1m/1m, which can accommodate 144 molds of wet cake of size 5 cm diameter and 5 cm height. One phase of the mold will be resting on the plate. For the given drying rate data to dry the material 125 kg (bone dry), how much time will be required? **14**
Data:
Initial moisture content = 0.2 kg/kg of dry solid
Final moisture content = 0.02 kg/kg of dry solid
Density of wet cake = 1740 kg/m^3

Moisture Content, X, kg/kg of dry solid	0.3	0.2	0.14	0.096	0.056	0.046	0.026	0.016
Rate, N, kg/hr m^2	1.71	1.71	1.71	1.46	1.29	0.88	0.54	0.376

OR

Q.4 A rotary dryer using counter-current flow is to be used to dry 12,000 kg/hr of wet salt containing 5% water (wet basis) to 0.10% water (wet basis). Heated air at 147^{o}C with 50^{o}C wet bulb temperature is available. The specific heat of salt is 0.21 kcal/kg^{o}C. The outlet temperature of air and salt are 72^{o}C and 93^{o}C respectively. Assuming suitable mass velocity of gas (5000 kg/hr-m^2), calculate the length and **14**

diameter of dryer required.

Data:

$\lambda_{(water)}$ at 50°C: 569 kcal/kg

Specific heat of solids C_{ps}: 0.21 kcal/kg°C

Specific heat of water vapor C_{pv}: 0.45 kcal/kg°C

Specific heat of liquid C_{pL}: 1 kcal/kg°C

Specific heat of dry air: 0.2526 kcal/kg°C

Temperature of entering air: 30°C

Q.5 Flaked soya bean are to be leached with hexane to remove the soya bean oil 0.3 m thick layer of flakes (0.25 mm flake thick) will be feed on to a slowly moving belt, which passes under a series of continuously operated spray. As the solid passes under each spray it is showered with liquid which percolates through the bed and collects in a draft below the belt and recycled by the pump to the spray. The spacing of the spray is such that the solid is permitted to draw six steps before it reaches the next tray. The solvent also passes from draft to draft in a direction counter current to stage-wise operation is mounted each spraying is draining constituting one stage. Experiments shows that the flakes retained solution after 6 min drain time to an extent depending upon on oil content of the solution as follows: **14**

Wt.% of oil in solution (y*)	0	20	30
Ratio (C/A+C)	0	0.2	0.3
Kg of solution retained/kg of insoluble solid	0.58	0.66	0.70

It will be assumed that the retained solution contains only oil in the drained flakes. Soyabean flakes entered containing 20% oil and are to be leached to 0.5% oil (on a solvent free basis). The net forward flow of solvent is to be 1 kg Hexane introduced on fresh solvent if free of oil. The solvent draining from the flakes is generally free of soilds, except in the first stage. The rich miscella contains 10% of insoluble solids in the feed as a suspended solid which falls through the preparation of the belt during leaching. How many stages are required? What are the dimensions of belt required if the contact time is 6 min and drainage time is 6 min?

OR

Q.5 In a steam super heater having suggested layout of tubes ($S_1=S_2=2d_o$), 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: CO_2 = 13%, H_2O = 11%, N_2 = rest

S_1 = Transverse pitch

S_2 = longitudinal pitch

$\sigma = 0.567 * 10^{-7}$ W/m^2 °K^4

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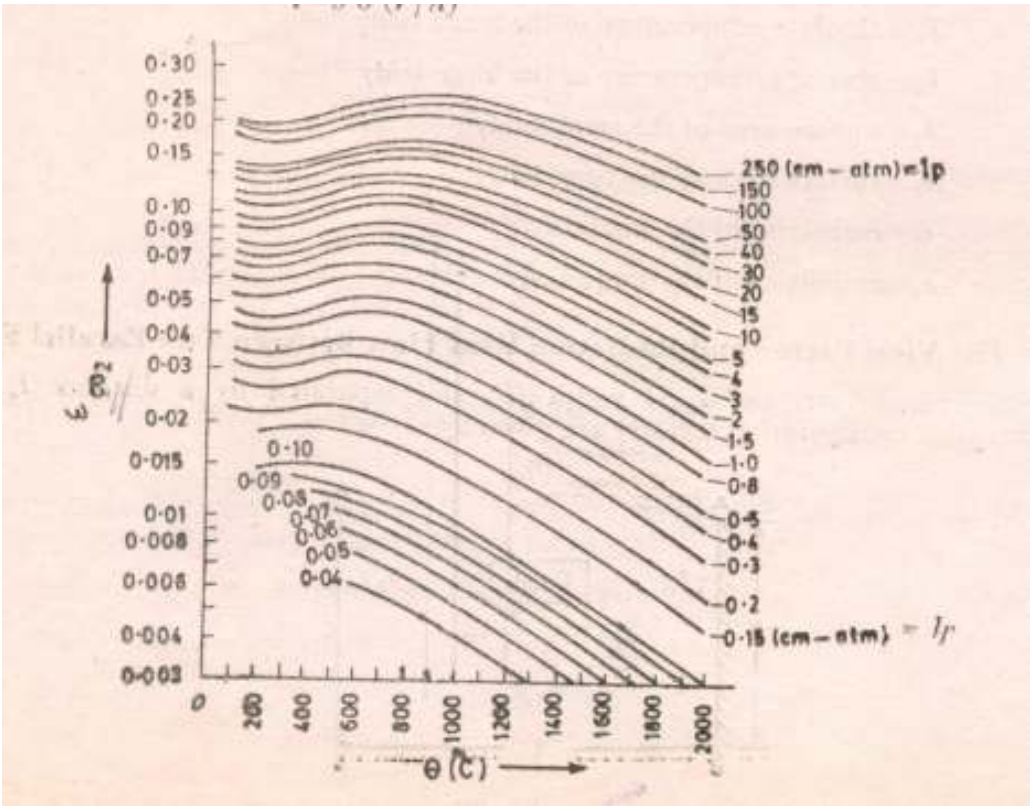

Fig. A Emissivity of Carbon-dioxide

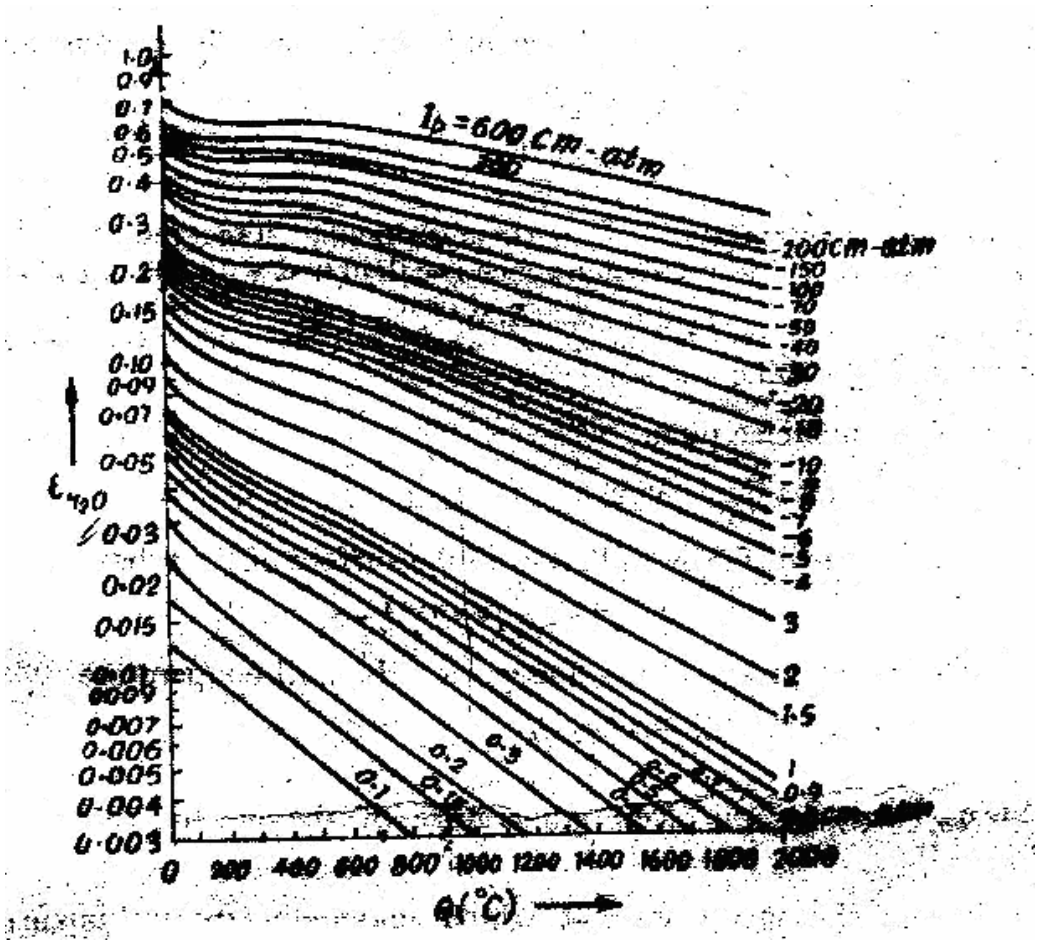

Fig. B Emissivity of Water Vapour

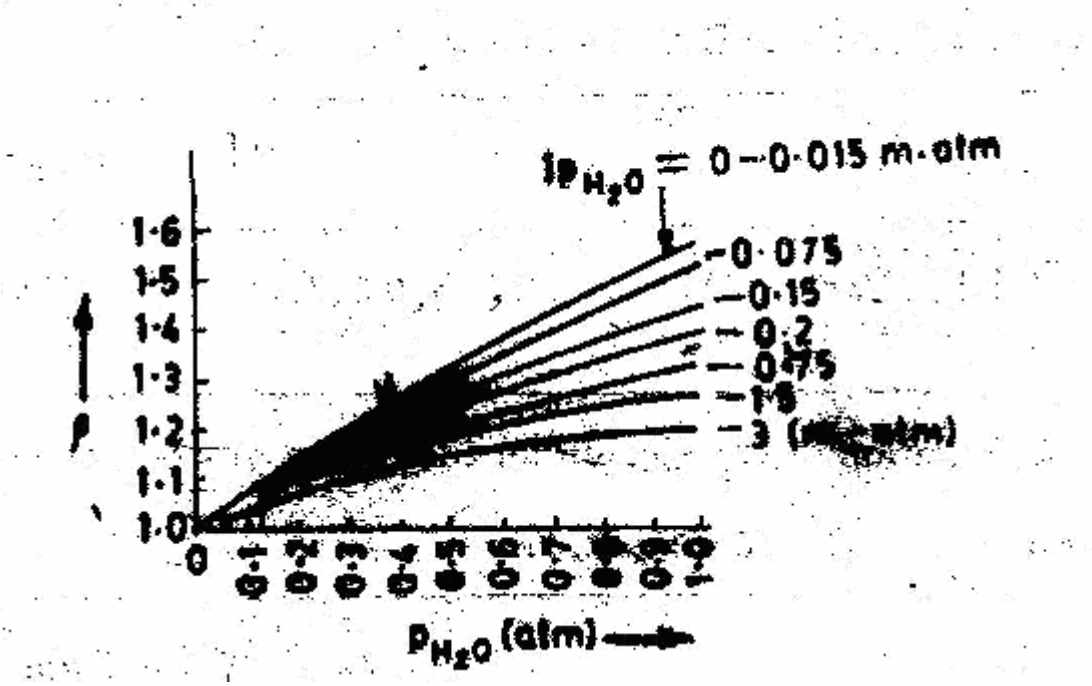

Fig. C β vs p_{H2O}

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