AGRICULTURAL AND FOOD ENGINEERING DEPARTMENT
INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

End-Spring Semester ~~Examination~~ 2008-09 **Full Marks: 50**
Date of examination: 22-04-2009 FN **Time : 3 Hrs**
Course: M.Tech (DFE+~~PHE), DD~~(IVth & Vth year) and IV th year B.Tech(H)
Subject: No. -AG60096 **Subject Name Food Plant and Equipment Design**
No. of Students: 26

Instructions: Answer **question 1** in Part A and **three** from Part B. Use of Steam Table is permitted. Make reasonable assumptions wherever necessary. Question paper contains two pages

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Part A

1\. (a) Milk is sterilized by direct mixing with steam at 4.76 bar. The feed enters the heater at 80° C and is heated instantaneously to 150° C. After holding for 2.5 s, the milk is vacuum flashed to bring it to original concentration of milk in expansion vessel. The specific heat of milk and water are 3.90 and 4.20 kJ/(kg ° C) respectively . Determine (i) amount of steam added per kg to the milk. (ii) vacuum required to be maintained in the expansion vessel for cooling of milk and (iii) milk outlet temperature of the expansion vessel.

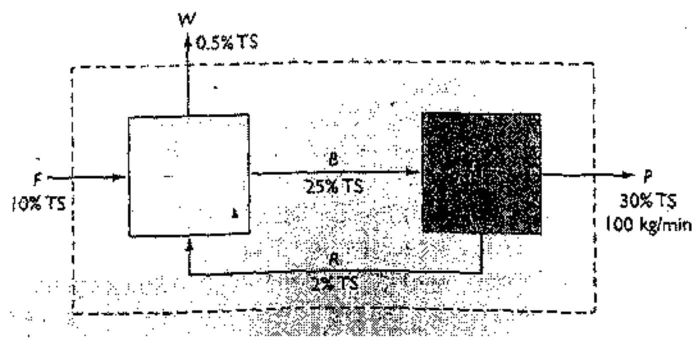
(b) A sweetened condensed milk manufacturing plant receives 20,000 litres of milk testing 6.0 % fat and 10 % solid not fat (SNF) per day. Skim milk powder with negligible fat and 4 % moisture content and sugar (sucrose) are available for standardization. Calculate the amount of skim milk powder and sugar required per day if the sweetened condensed milk manufactured should contain 9 % fat, 22 % SNF and 44 % sugar. Take specific density of milk is 1030 kg/m^3.

(c) Explain in brief the procedure for planning and designing of a food processing plant. What are the major utilities requirements in food processing plant? How do you determine the utilities requirement for a multi-product dairy plant? [5+5+4=14]

Part B

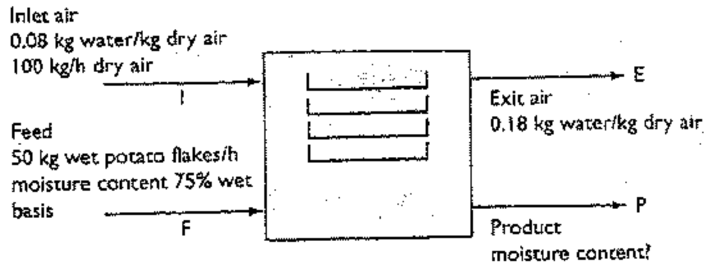
(Answer any three)

Q.1 A membrane separation system is used to concentrate total solids (TS) in a liquid food from 10% to 30%. The concentration is accomplished in two stages with the first stage resulting in release of a low-total-solids liquid stream. The second stage separates the final concentration product from a low-total-solids stream, which is returned to the first stage. Determine the magnitude of the recycle stream when the recycle contains 2% TS, the waste stream contains 0.5% TS, and the stream between stages 1 and 2 contains 25% TS. The process should produce 100 kg/min of 30% TS. [12]



Q.2 Potato flakes (moisture content = 75% wet basis) are being dried in a concurrent flow drier. The moisture content of the air entering the drier is 0.08 kg of water per 1 kg dry air. The moisture content of air leaving the drier is 0.18 kg water per I kg of dry, air. The air flow rate in the drier is 100 kg dry air per hour. As shown in Fig., 50 kg of wet potato flakes enter the drier per hour. At steady state, calculate the following:

(a) What is the mass flow rate of "dried potatoes"?
(b) What is the moisture content, dry basis, of "dried potatoes" exiting the drier? [12]

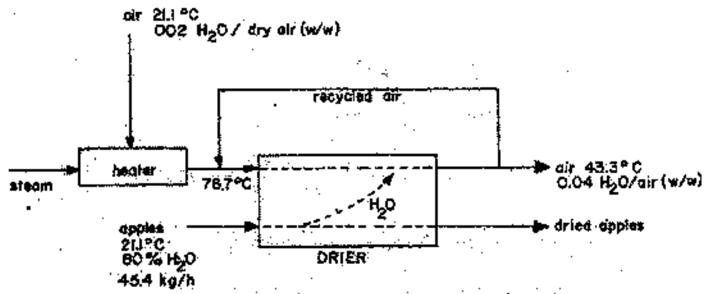


Q.3. Calculate the amount of saturated steam at 121.1 °C that must be supplied to a dehydrator per hour. Steam condenses in the heater which heats the drying air from steam to water at 121.1°C. The dehydrator is operated as follows: Apples at 21.1 °C enter the dehydrator with 80 % moisture and leave the dehydrator at 37°C and 10% moisture. One hundred pounds per hour of fresh apples enter the drier. Fresh air at 21.1°C and a humidity of 0.002 kg H_2O/kg dry air enters the drier, mixes with recycled hot air until the humidity is 0.026 kg H_2O/kg dry air, and is heated to 76°C using steam in a finned heat exchanger. Hot air leaves the heater at 43.3°C and a humidity of 0.04 kg H_2O/kg dry air. [12]

Given, C_{pair} = 1008 J/kg K; C_{apple} = 3349 M+ 837.36 J/kg K, (M = moisture content in apple, in fraction);

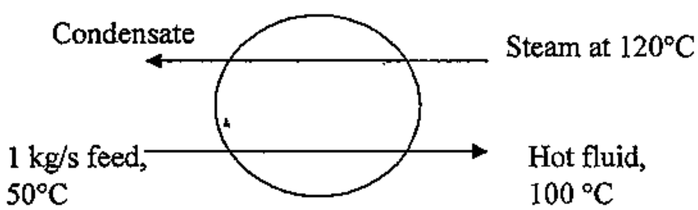
$$\lambda = 2502.4 - 2.402T, kJ/kg; \; H_s = 2502.6 + 1.7755T \quad \ln P = 18.6556 - \frac{5217.635}{T+273}$$

T is in °C



Q.4. A typical flow sheet for a steam heater is presented in the Figure. The process stream with a flow rate 1 kg/s at temperature 50°C is heated in a heat exchanger to temperature 100°C. Saturated vapuor with a flow rate at temperature 120°C is used as a heating medium. The condensate is assumed to be saturated liquid with the same flow rate and temperature.

The heat exchanger has a total heat transfer area A (m^2), through which heat Q (kW) is transferred using a driving force ΔTm (°C).



Show (a) process model formulation, (b) process variables, (c) degree of freedom, (d) Process specifications, (e) design variables, (f) technical data (g) solution algorithm following the Lee-Christensen-Rudd method and (h) the final model solutions for the parameters. Given overall heat transfer coefficient = 0.5 kW/m2 K; heat capacity of fluid = 3.50 kJ/kg K; latent heat of vapourization = 2200 kJ/kg [12]

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