INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date: 22.04.2010 (AN) Time: 3 hours Full Marks 50 No. of students: 6+1 (RS)
Spring Semester 2010 Deptt.: AgFE Subject No.: AG60136
I year M.Tech.(PHE) Subject: Advances in Drying and Dehydration

Instruction: Attempt any three questions from Part A and all the questions from Part B.

PART A

Q1. a) Graphically represent the variation in moisture content and drying rate with time during the drying of biological materials in general. [3]

b) How does single grain drying differ batch drying of cereal grains? [2]

c) Corn at 35% (d.b.) moisture content is dried in a bin. The grain bed depth is 2.5 m, air flow is 8.6 $m^3min^{-1}m^{-2}$, grain dry matter bulk density is 600 kgm^{-3}, inlet air temperature and humidity are 30°C and 42% respectively, specific volume of air is 0.87 m^3kg, equilibrium moisture content is 8.6% (d.b.), and exit air temperature is 19.2°C. The half response time is 4.8 hour. Heat of vaporization is 2,783 $kJkg^{-1}$ and specific heat is 1.004 $kJkg^{-1}°C^{-1}$. Calculate the moisture content at 0.5 m and 2.0 m after 7000 minutes. [5]

Q2. a) Derive the fundamental differential equation of diffusion in a rectangular parallelopiped isotropic medium. [4]

b) The wet feed material to a continuous dryer contains 50% water on wet basis and is dried to 27% by countercurrent air flow. The dried product leaves at flow rate of 907.2 kg/h. Fresh air to the system is at 25.6°C & has a humidity of H = 0.007 kg/kg dry air. The moist air leaves the dryer at 37.8 °C and H = 0.02. Part of the exit air is recirculated and mixed with the fresh air before entering the heater. The heated mixed air enters the dryer at 65.6°C and H = 0.010. The solid enters at 26.7 °C. Calculate the fresh air flow, the percent air leaving the dryer that is recycled, the heat added in the heater and the heat loss from the dryer. [6]

Q3. a) What is mathematical modeling? [1]

b) Find the suitability of Page model, Lewis model and Logarithmic model based on R^2 and standard error for thin layer drying modeling of the following moisture content versus time data.

Time (min)	0	15	30	45	60	75	90	120	150	180	210
Moisture Ratio	1	0.75	0.61	0.46	0.34	0.24	0.16	0.07	0.02	0.01	0.01

[5]

c) Derive the formula for time requirement in freeze drying using uniformly retreating ice front approach. Assume any data if required. [4]

Q4. Write short notes:

a) Water activity and shelf life of biological materials
b) Minimum fluidization velocity
c) Resistance of grain to air flow
d) Freeze drying
e) In-bin drying [2x5]

PART B

Q5. a) Classify the heat pump dryers based on different criteria. [4]

b) Describe the heat pump assisted multi-mode drying system with the help of a suitable block diagram. [6]

Q6. a) A continuous counter current dryer is being used to dry 720 kg dry solids/h containing 0.54 kg total moisture/kg dry solid. The solid enters at 25.3°C and is to be discharged at 53°C. The dry solid has a heat capacity of 1.465 kJ/kg.K which is assumed constant. Heating air enters at 87.5°C having humidity of 0.014 kg H_20/kg dry air and is to leave at 35°C. Calculate the air flow rate and the outlet humidity assuming no heat loss in the dryer. Latent heat of vaporization is given as 2750 kJ/kg. [6]

b) Enlist different types of fluidized bed dryers and explain JetZone fluidized bed dryer with the help of a suitable diagram [4]
