INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date .....FN/AN, Time: 3 Hrs, Full Marks 50, Deptt Agric & Food Engg

No. of Students 15/26 End Autumn Semester Examination 2011-12

Sub. No. AG60023/AG60301

Sub. Name Dairy and Food Engineering Operations – I (Dual Degree, DFE)
Advanced mechanical Operations in Food Processing (M. Tech, FPE)

4th Year M. Tech (Dual)/ M.Tech(FPE)

Instruction: Answer any five from the following. Any assumption of data should be justified

Q.1 An emulsion is to be prepared at 40°C using two liquids; liquid A (continuous phase) and liquid B (dispersed phase), in the volume ratio of 60:39.99 % along with lecithin as emulsifier (0.01% v/v). Liquid A is pseudoplastic fluid (K=40 Pas^n; n' = 0.65 and ρ = 1050 kg m^{-3}) and liquid B is dilatant fluid (K = 12 Pas^n; n' = 1.30 and ρ = 953 kg m^{-3}). A baffled tank of 1.2 m in diameter, fitted with a 0.4 m flat disc turbine, (rotating at 200 rpm) is used. Calculate power requirement of the motor if the power transmission efficiency is 55%. [10]

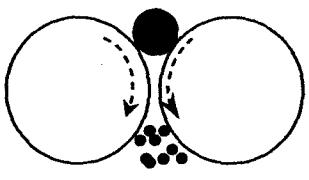
Q.2(a). A cyclone separator 0.4 m in diameter and 1.5 m long has a circular inlet of 100 mm in diameter and an outlet of same size. Draw the sketch of the system and explain how it works to separate the particles from the dust-contaminated air. [5]

(b) This cyclone is used to separate dust particles from air that enters the system at 2.5 ms^{-1}. Calculate the particle cut diameter. Given, ρ_{air} = 1.3 kgm^{-3}; μ_{air} = 1.8 x 10^{-2} cP and ρ_p = 2000 kgm^{-3}. [5]

Q.3(a) Draw a schematic of a rotary vacuum filter with proper labels (**use pencil to draw figure**). [4]

(b) A rotary vacuum filter with 25% submergence is used to filter extracted sugar cane juice containing 112 kg suspended solids/m^3 of juice. The pressure differential applied across the filter medium is 50 kPa. If the ratio of weight of wet cake deposited on the filter medium to that of the dry cake is 2.25, calculate the filter area required to obtain 50 litre of filtered juice per minute when filter cycle is 3 minutes. The deposited cake has a compressibility factor of 0.3 and α_{om} = 1.9 x 10^8 m kg^{-1}. Assume filter medium has negligible resistance. Given, ρ = 1011 kgm^{-3}; and μ = 1 cP. [6]

Q.4(a) A pilot scale roll crusher was developed to make corn grits (see figure). Obtain the limiting condition for grinding to occur. [5]



(b) It has been found that for a feed rate of 30.2 kg per minute of corn (80% of which passes through 8 mm screen but retained on 6 mm screen) power requirement was 11.34 W for increase in surface area only. The cumulative screen analysis of the product showed that 80% of the product passes through 2 mm size screen but retained on 1 mm size screen. Using Bond equation, calculate power requirement when the size of the grit should be such that 80% of the particle passes through 1mm screen but retained on 0.5 mm screen.

Q.5(a) Name each of the equations and define all the symbols with proper SI unit. [(½ + ½) x 3 = 3]

(i) $\frac{dt}{dV} = \frac{1}{q} = \frac{\mu}{A(\Delta P)}\left[\frac{Vc\alpha}{A} + R_m\right]$

(ii) $\frac{P}{\dot{m}} = W_i\left[\frac{100}{\bar{D}_{sp}}\right]^{\frac{1}{2}}\left[1 - \frac{1}{\sqrt{q}}\right]$

(iii) $\frac{\Delta P}{\Delta L} = \frac{150\mu u(1-\varepsilon^2)}{(\phi_s D_p)^2\varepsilon^3} + \frac{1.75\rho u^2(1-\varepsilon)}{\phi_s D_p \varepsilon^3}$

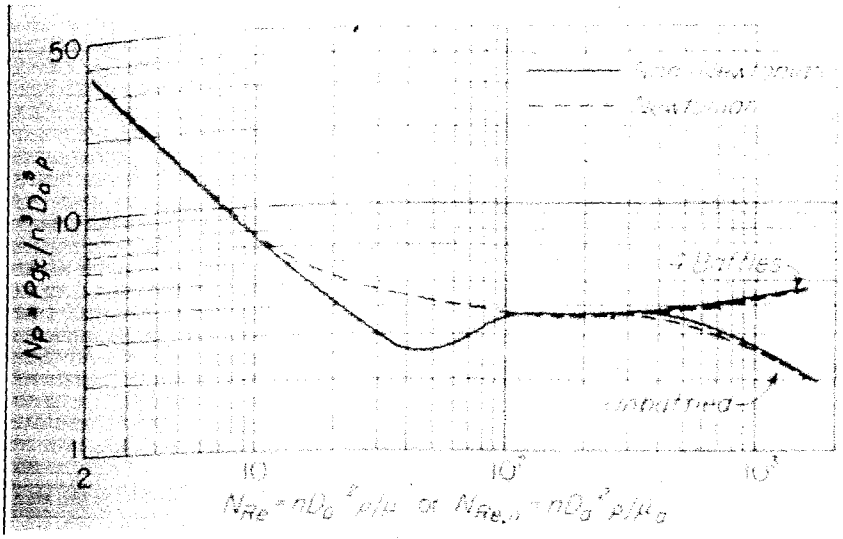
(b) The mean particle size for the entire lot can be obtained by summing over the entire range as

$D_{q,p}^{q-p} = \frac{\sum_{i=1}^{n} D_i^q N_i}{\sum_{i=1}^{n} D_i^p N_i}$. Give **FIVE** expressions for mean particle size in different ways (e.g., Number-length mean diameter is $D_{1,0} = \frac{\sum N_i D_i}{\sum N_i}$) [1 x 5 = 5]

(c) Derive the critical speed for a ball mill [2]

Q.6 Write short notes on ~~(any five)~~ [2x5 = 10]

a) Sterilization of air by fibrous bed
b) Solid-liquid mixing equipments for making dough
c) Liquid flow regimes with propeller and turbines
d) Importance of agitation and mixing in food industries
e) Different separation processes in grain processing industries



Hints:

$$\gamma = 11\ n = 38n\left(\frac{D_a}{D_t}\right)$$

$$\mu = \frac{\mu_1}{v_1}\left\{1 + \left[1.5\frac{\mu_2 v_2}{(\mu_1 + \mu_2)}\right]\right\} = \mu_1^{v_1}\mu_2^{v_2}$$

$$D_{pc} = \left[\left\{\frac{1}{\frac{1.41(\rho_p - \rho)}{\rho\mu}}\right\}\left\{\frac{d^5}{Dz}\right\}\left(\frac{1}{G}\right)\right]^{\frac{1}{2}}$$

$$\frac{m_c}{A_T} = \left[\frac{2(\Delta P)^{1-s} cfn}{\mu\alpha_{0m}}\right]^{\frac{1}{2}}$$

$$c = \frac{c_s}{1 - Rc_s}\ ;\ R = \left(\frac{m_F}{m_c} - 1\right) \times \frac{1}{\rho}$$