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INTERNATIONAL CENTRE FOR APPLIED SCIENCES
(Manipal University)

III SEMESTER B.S. DEGREE EXAMINATION – NOV. / DEC. 2016

SUBJECT: FLUID FLOW OPERATIONS IN BIOPROCESSING (BT 231)

(BRANCH: INDUSTRIAL BIOTECHNOLOGY)

Friday, 25 November 2016

Time: 3 Hours **Max. Marks: 100**

- ✓ **Answer ANY FIVE full Questions.**
- ✓ **Missing data, if any, may be suitably assumed**

1A. What is relative density of the fluid?

1B. A U-tube manometer filled with mercury is connected between two points in a pipe line. If the manometer reading is 25 mm. Calculate pressure difference between two points.

a) When water is flowing through pipe.

b) When air at atmospheric pressure and 20°C is flowing.

1C. A cylindrical tank of cross sectional area 750 mm^2 and 2.8 m height is filled with water upto a height of 1.5 m and remaining with oil of specific gravity 0.875. The vessel is open to atmospheric pressure. Calculate

a) Intensity of pressure at the interface

b) Absolute and gauge pressures on the base of the tank in terms of water head, oil head and N/m^2

c) The net force experienced by the base of the tank.

(2+6+12) = 20Marks)

2A. Explain in detail about the Reynold's experiment. Mention the significance of the Reynold's number.

2B. An oil is being pumped inside a 10 mm dia pipe @ N_{Re} of 4000. The oil density is 875 kg/m^3 and viscosity is $2.5x10^{-2}$ Pa-s.

a) What is the velocity in the pipe?

b) It is desired to maintain the laminar flow with the same velocity as in part (a) using a second fluid with a density of 920 kg/m^3 and viscosity $1.5x10^{-2}$ Pa-s. What pipe diameter should be used?

(12+8 = 20 Marks)

3. A pump draws a liquid solution of specific gravity 1.85 from an open storage tank through a 3.068"ID Schedule 40 steel pipe. The efficiency of the pump is 75%. The velocity in suction pipe is 0.925 m/s. The pump discharges through a 2.067"ID Schedule 40 steel pipe to an open overhead tank. The end of the discharge pipe is 20 m above the level of the liquid solution in the feed tank. The friction losses in the entire piping system are 25.9 J/kg. What pressure must the pump develop? What is the horsepower delivered to the fluid by the pump?

(20 Marks)

4A. Molasses for microbial fermentation having a density of 1.25 g/cc & viscosity of 1.5 centipoise is to be pumped from a storage tank to the top of a fermenter 25 m above the molasses level in tank. It is desired to deliver 0.46 m^3/min of molasses at a pressure 2 atm. The steel pipe consists of 120 m length of straight pipe of 7.5 cm internal diameter with 8 elbows of 90° and 5 gate valves. Calculate the HP, if the efficiency of the pump is 85%. Equivalent lengths of elbow and gate valve are 30D and 200D respectively.

4B. A small capillary with an ID of 2.25 mm and a length 0.315 m is being used to continuously measure the flow rate of a liquid having a density of 875 kg/m^3 and viscosity 1.53x10^{-3} Pa-s. The pressure drop reading across the capillary during flow is 0.0675 m of water (density 996kg/m^3). What is the flow rate?

(15+5 = 20 Marks)

5A.Discuss about the boundary layer formation in straight pipes and boundary layer separation.

5B. Particles having a size of 0.10 mm, a shape factor of 0.85, and a density of 1250 kg/m^3 are to be fluidized using air at 25°C and 201.65 kPa abs pressures. The void fraction at minimum fluidizing conditions is 0.41. The bed diameter is 0.68 m and the bed contains 320 kg of solids. Air properties are viscosity = 1.85x10^{-2} cP, density = 2.174 kg/m^3

a) Calculate the minimum height of the fluidized bed
b) Calculate the pressure drop at minimum fluidizing conditions
c) Calculate the minimum fluidizing velocity.

(10+10 = 20 Marks)

6A. Discuss the mode of transportation available for the gases. Compare among them.

6B. A flue gas (molecular weight of 30.7 g/gmol) is moved by a centrifugal blower (a blower operates as a pump, but is suitable for gases) from conditions *at rest* at 353°K and 750 mm Hg pressure, to be discharged at 800 mm Hg and a velocity of 38 m/s. The volumetric flow rate is 57 m^3/min. The blower operates isothermally. Calculate the blower power required if the efficiency is 65%. State your assumptions clearly.

(8+12 = 20 Marks)

7A. Explain in detail about any three meter used for the flow rate measurement.

7B. A venturimeter is to be fitted in a pipe of 250 mm diameter where pressure head is 7.6 m of flowing fluid and the maximum flow is 8.1 m^3/minute. Determine the least diameter of the throat to ensure that the pressure head does not become negative. Take the coefficient of venturimeter as 0.96.

(15+5= 20 Marks)

8A. How various types of impellers aid agitation of the fluid?

8B. Mention the purposes of agitation in the fermentation.

8C. Examine the way of avoiding the circulatory flow in agitated vessel.

8D. Compute the power requirement to drive the impeller in agitated vessel.

(5+5+5+5 = 20 Marks)

List of formulae

$$\boxed{N_{\mathrm{Re},p} = \left|\frac{1}{1-\varepsilon}\right| D_p v_s \frac{\rho}{\mu}}$$

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

$$\boxed{\frac{\Delta P}{L_{mf}} = (1-\varepsilon_{mf})(\rho_p - \rho)g}$$

$$\boxed{v_{mf} \approx \frac{g(\rho_p - \rho)}{150\,\mu}\frac{\varepsilon_{mf}^3}{1-\varepsilon_{mf}}\phi_s^2 D_p^2}$$

$$\boxed{v_{mf} \approx \left[\frac{\phi_s D_P g(\rho_p - \rho)\varepsilon_{mf}^3}{1.75\rho}\right]^{1/2}}$$

$$\boxed{\frac{150\ (1-\varepsilon_{mf})}{\phi_s^2\ \varepsilon_{mf}{}^3} N_{\mathrm{Re},mf} + \frac{1.75}{\phi_s\ \varepsilon_{mf}{}^3}\left(N_{\mathrm{Re},mf}\right)^2 = \left(\rho D_P^3 \big/ \mu^2\right) g(\rho_p - \rho)}$$

$$\boxed{N_{\mathrm{Re},mf} = \left[33.7^2 + 0.0408\left(\rho D_P^3 \big/ \mu^2\right) g(\rho_p - \rho)\right]^{1/2} - 33.7}$$

$$\boxed{v_t = \frac{g D_p^2(\rho_p - \rho)}{18\mu}}$$

$$\boxed{v_t = 1.75\sqrt{\frac{g D_p(\rho_p - \rho)}{\rho}}}$$

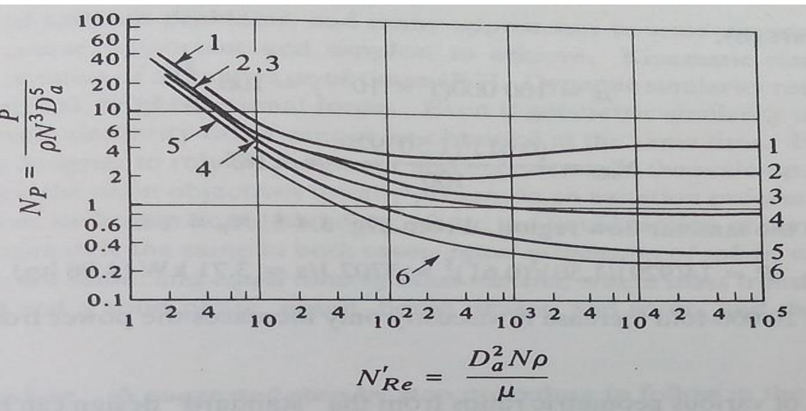

FIGURE 3.4-5. *Power correlations for various impellers and baffles (see Fig. 3.4-3c for dimension D_a, D_t, J, and W).*

Curve 1. *Flat six-blade turbine with disk (like Fig. 3.4-3 but six blades); $D_a/W = 5$; four baffles each $D_t/J = 12$.*

Curve 2. *Flat six-blade open turbine (like Fig. 3.4-2c); $D_a/W = 8$; four baffles each $D_t/J = 12$.*

Curve 3. *Six-blade open turbine (pitched-blade) but blades at 45° (like Fig. 3.4-2d); $D_a/W = 8$; four baffles each $D_t/J = 12$.*

Curve 4. *Propeller (like Fig. 3.4-1); pitch = $2D_a$; four baffles each $D_t/J = 10$; also holds for same propeller in angular off-center position with no baffles.*

Curve 5. *Propeller; pitch = D_a; four baffles each $D_t/J = 10$; also holds for same propeller in angular off-center position with no baffles.*

Curve 6. *High-efficiency impeller (like Fig. 3-4-4a); four baffles each $D_t/J = 12$.*