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Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)



III SEMESTER B.TECH (BIOTECHNOLOGY)

END SEMESTER EXAMINATIONS, NOV/DEC 2015

SUBJECT: Fluid Flow Operations In Bioprocessing [BIO 2106]

REVISED CREDIT SYSTEM

Time: 3 Hours

MAX. MARKS: 50

Instructions to Candidates:

- ✤ Answer ALL the questions.
- Missing data may be suitable assumed.

1A.	State the SI-dimensions of dynamic and kinematic viscosity, respectively. Also provide approximate values (with two significant digits) for water and air at standard room conditions (20°C, 1 atm). At around standard room conditions, what are the separate effects of changing the pressure and temperature, respectively?	3
1B.	Select a device which is required to measure the pressure difference between two different pipes. Justify your selection with its principle of working.	3
1C.	A hydrocarbon liquid enters a simple flow system at an average velocity of 1.282 m/s, over an area 43.3 cm ² with density 902 kg/m ³ . The liquid is heated in the process and exit density is 875 kg/m ³ and flowing over an area 52.6 cm ² . The process is at steady state, calculate the mass flow rate at entrance and exit and calculate the average velocity at point 2.	4
2A.	Calculate the volumetric flow rate of water (viscosity 0.85 cP) at the critical velocity flowing through 25 mm i.d pipe.	3
2B.	A fluid is flowing through a 5 cm diameter pipe at a velocity of 2 m/s. Suddenly it enters into a large cross sectional part of the pipe having a diameter of 10 cm. Calculate the frictional loss due to sudden expansion.	2
2C.	60 % Sulphuric acid is to be pumped through a 25 mm i.d lead pipe ($k = 0.002$) at a rate of 4000 cm ³ /s. It is desired to raise it to a height of 25 m. The pipe is 30 m long and includes two right angled bends. Calculate the theoretical power required. Specific gravity of acid 1.531, kinematic viscosity of acid 0.425 cm ² /s. Assume that 0.8 velocity heads are lost through each bend.	5
3A.	A regenerative heater is packed with a bed of 6 mm spheres. The cubes are poured into the cylindrical shell of the regenerator to a depth of 3.5 m such that the bed porosity was 0.44. If air flows through this bed entering at 25°C and 7 atm abs and leaving at 200°C, calculate the pressure drop across the bed when the flow rate is 500 kg/h per square meter of empty bed cross section. Assume average viscosity as 0.025 cP and density as 6.8 kg/m ³ .	5
3B.	Calculate the settling velocity of dust particles of 60 mm diameter in air at 21°C and 100 kPa pressure. Assume that the particles are spherical of density 1280 kg m ⁻³ , and the viscosity and density of air are 1.8×10^{-5} N s m ⁻² and 1.2 kg m ⁻³ . If the diameter of dust particle is 10 mm, then what is the terminal velocity at same settling condition?	3

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3C.	A tower having a diameter of 0.1524 m is being fluidized with water at 20.2°C. The uniform spherical beads in the tower bed have a diameter of 4.42 mm and a density of 1603 kg/m ³ . Estimate the minimum fluidization velocity and compare with the experimental value of 0.02307 m/s of Wilhelm and Kwauk.	2
4A.	Identify a mechanical device which delivers the liquid at several thousands of kPa pressure. Explain the working principle of that with a neat schematic diagram.	3
4B.	A 5 stage compressor is to compress 7.5×10^{-3} kmol/s of nitrogen gas ($\gamma = 1.4$) at 27°C and 135.5 kPa abs to 55.56 Mpa abs. Calculate the power required if the efficiency is 75% and the compression is adiabatic. Also calculate the outlet temperature.	3
4C.	An orifice meter is used to measure the flow rate of water flowing in a pipe line of 78 mm I.D. The orifice diameter is 15 mm. Mercury manometer reads 18 cm. The volumetric flow rate in this case is 719 cm ³ /s. Calculate the coefficient of discharge of the meter. If the pressure drop is decreased to 9 cm of Hg, what will be the flow rate?	4
5A.	A tank 1.2 m in diameter and 2 m high is filled to a depth of 1.2 m with a latex having a viscosity of 10 P and a density of 800 kg/m ³ . The tank is not baffled. A three-blade 360 mm diameter propeller is installed in the tank 360 mm from the bottom. The motor available develops 8 kW. Is the motor adequate to drive this agitator at a speed of 800 r/min? What power is required for the mixing operation, if a propeller 400 mm in diameter turning at 15 r/s is used and if four baffles, each 120 mm wide, are installed?	6
5B.	Describe the agitation of fermentation broth in a reactor vessel with different impellers used for it. And also the flow patterns during agitation in vessel. How do you calculate the power required for an aerobic and anaerobic process?	4



 ε^{3}

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List of formulae

$$N_{\text{Re},p} = \left| \frac{1}{1 - \varepsilon} \right| D_p v_s \frac{\rho}{\mu}$$
$$\frac{\Delta P}{L} = \frac{150\mu v_s (1 - \varepsilon)^2}{\phi_s^2 D_p^2 \varepsilon^3} + \frac{1.75 \rho v_s^2 (1 - \varepsilon)}{\phi_s D_p \varepsilon^3}$$

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

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

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

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

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

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

$$v_t = 1.75 \sqrt{\frac{gD_p(\rho_p - \rho)}{\rho}}$$



