BACHELOR OF ENGINEERING IN CHEMICAL ENGINEERING EXAMINATION, 2019

(2nd Year, 2nd Semester)

MECHANICAL OPERATIONS

Time : Three hours   Full Marks : 100

(50 marks for each Part)

Use separate Answer - script for each Part

PART - I

Question# 1 is compulsory. Answer any two from the rest. To the point answer is encouraged

1. (a) Galena and limestone having the ratio of 3:7 (feed size 100 kg) is treated in elutriator using 7mm/s of water flowing upward. The size distribution of each material is shown in the table. If Stokes' law is applicable, find the percentage of Galena and Limestone in overflow and in underflow. (Densities of Galena and limestone are 7500 and 2700 kg/m^3, respectively) (8)

Particle Size	20	30	40	50	60	70	80	100
% of Mass	10	22	43	55	62	70	77	90

(b) A calcium–carbonate slurry is to be filtered in a press having a total area of 16 m^2 and operated at a constant pressure drop of 2 atm. The frames are 36 mm thick. Assume that the filter medium resistance is $1.55*10^{10}$/ ft. Calculate volume of filtrate obtained in one cycle filtration time. (8)

Given: Mass Ratio = 2; $\alpha = 2.9*10^{10}(\Delta p)^{0.26}$; Slurry Concentration = 14.7 lb/ft^3; $\rho_{Filtrate}$ = 62.3 lb/ft^3

(c) In a ball mill of diameter 2000 mm, 100 mm diameter steel balls are being used for grinding. Presently, for the material being ground, the mill is run at 15 rpm. At what speed will the mill have to be run if the 100 mm balls are replaced by 50 mm balls, all the other conditions remaining the same? (4)

Or

A pair of rolls is to take a feed equivalent to spheres of 4.0 cm in diameter and crush them to spheres having 1.0 cm in diameter. If the coefficient of friction is 0.29, what would be the diameter of rolls?

(d) A fluid of viscosity $5*10^{-2}$ Pa s and density 2000 kg m^{-3} is agitated in an 80 m^3 baffled tank employing an anchor (Np'=0.35) of 2.0 meter in diameter. Calculate the power required and circulation time for a stirrer speed of 6 s^{-1}. (6)

Or

In a settling cylinder of 10 meter height, the settling tests were performed for activated sludge. If the initial solid concentration is 4.0 gm/L. Determine the area of the chamber in order to have final thick sludge concentration of 60 gm/L. Flow rate is 400m^3/Day.

Height (meter)	10	8.5	7	6	5	4	3	2	1.5
Time (hours)	0	1	2	3	4	5	6.5	8.5	10

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2. (a) State the importance of an Eductor over Rotary valve.

(b) Discuss about the arrangements made to protect the variable speed pumps at low discharge. (Schematic preferred)

(c) Write the operating principle of Axial Compressors.

(d) "Positive displacement pumps shouldn't operate against closed valves on the discharge side of the pump"-why? (2+4+4+2)

3. (a) Write down the principle of operation of a Hydraulic Jig.

(b) "Sometimes it is needed to apply secondary air flow within the cyclone separator"- why?

(c) Show the baffle arrangement and flow pattern in an agitated vessel during mixing of high viscous fluid.

(d) Schematically show how an 'electrostatic separator' **or** a 'Venturi Scrubber' works. (4+2+2+4)

4. (a) Why "closed circuit grinding" is important-explain with flow sheet. Define work index.

(b) "Accurate measurement of power requirement is difficult for Gassed fluid"-Explain.

(c) How to interpret the 'Scaling up of Mixing'

(d) Discuss the 'reverse air cleaning' method of Baghouses. (4+2+2+4)

BACHELOR OF CHEMICAL ENGINEERING EXAMINATION, 2019
(2nd Year, 2nd Semester)
Mechanical Operations
Answer any *two*
Assume any **missing** data
PART: II

1.a. A rotary drum filter of area 3m^2 operated with an internal pressure of 30 kn/m^2 and with 30% of its surface submerged in the slurry. Calculate the rate of production of filtrate and thickness of cake when it rotates at 0.0083 Hz if filter cake is incompressible and filter cloth has a resistance equal to that of 1 mm cake.

It is desired to increase the rate of filtration by raising the speed of rotation of the drum. If the thinnest cake that can be removed from the drum has a thickness of 5 mm, what is the maximum rate of filtration which can be achieved and what speed of rotation of the drum is required? (voidage of cake: 0.4, specific resistance of cake: 2x10^{12}/m^2, density of solids: 2000 kg/m^3, slurry concentration: 20% by mass of solids).

OR

Slurry is filtered in a plate & frame press containing 12 frames, each 0.3 m squre and 25 mm thick. During the first 180 s, the filtration pressure is slowly raised to the final value of 400 kN/m^2 and during this period, the rate of filtration is maintained constant. After the initial period, filtration is carried out at constant pressure and the cakes are completely formed in further 900 s. the cakes are then washed with a pressure difference of 275 kN/m^2 for 600 s, using *thorough washing*. What is the volume of filtrate collected per cycle and how much wash water is used?

A sample of the slurry was tested, using a vacuum leaf filter of 0.05 m^2 filtering surface and a vacuum giving a pressure difference of 71.3 kN/m^2. The volume of filtrate collected in first 300 s was 250 cm^3 and after a further 300 s, an additional 150 cm^3 was collected. It may be assumed that the cake is incompressible and cloth resistance is the same in the leaf as in the filter press.

b. Distinguish between (any **one**)

    i)   Classification and jigging
    ii) Frothers and collectors used in froth floatation cell

20+5

2.a. A centrifugal pump is situated 12.5 m vertically above the surface of liquid toluene in a tank which is open to atmosphere and at 30^0 C. Show that even if primed, the pump could not lift liquid toluene from the tank under this condition.

If the minimum NPSH of the pump is 0.65 m of water under this condition and inside pipe diameter is 2.3 cm, calculate

    i)   the maximum height at which the pump could be located above the toluene surface to deliver the liquid at 0.002 m^3/sec after priming, without risk of cavitation and if the

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suction pipe just dipped into the toluene in the tank. The pipe may be considered smooth.

ii) The maximum delivery rate after priming which could be obtained without the risk of cavitation if the pump were located 9 m above the liquid surface with suction pipe just dipping into the liquid (friction factor has same value as in section i).

Saturated vapour pressure of toluene at 30^0 C: 4.535 kPa

Density of toluene at 30^0 C: 867 kg/m^3· Viscosity of toluene at 30^0 C: 5.26x10^{-4} kg/m-s

Density of water: 867 kg/m^3

For turbulent flow in smooth pipe, $f = 0.0390 \times N_{Re}^{-0.25}$

b. In plate & frame filter press operation, rate of through washing would be one-quarter of simple washing rate. Explain why?

c. Describe the working principle of Blake type jaw crusher.

d. Based on the following requirement, which pump (positive displacement/ dynamic) do you select and why?

   i) high capacity
   ii) variable flow

e. Kick's law and Rittinger's law of crushing is applied over limited size range of particles but Bond's law is more realistic in estimation of energy required to crush a material. Explain.

OR

Discuss the effect of transport solid flux and settling solid flux in designing the area of a continuous thickener.

10+4+4+4+3

3.a. A mixture of an ore (sp. Gravity =2.0) and the gangue (sp. Gravity = 7.0) has to be separated in a hydraulic free settling elutritor. If the mixture has the following size distribution (valid for both ore & gangue) and a relation $\left(C_D = \dfrac{18.5}{N_{Re'p}^{0.6}}\right)$ is valid for the flow zone under consideration, estimate the upward velocity of hydraulic water to be used in the elutriator so that the entire ore is collected in the overflow. Will the overflow be gangue-free?

Particle size (mm)	Mass fraction
-0.58+0.49	0.62
-0.49+0.40	0.21
-0.40+0.36	0.17

OR

The reaction is to be carried out in an agitated vessel. Pilot plant experiments were performed under fully turbulent condition in a tank 0.6 m diameter, fitted with baffles and provided with a

flat bladed turbine. It was found that satisfactory mixing was obtained at a rotor speed of 4 rps, when the power consumption was 0.15 kw and Reynolds number 1, 60,000. What will be the power consumption and Reynolds number when same mixing performance prevails (i.e. constant impeller tip speed, constant power/unit volume) but if the linear scale of the equipment is increased 6 times?

b. Name two classifiers with justification which are used industrially for preparation of dry fractions of solids from its mixture.

c. Cyclones have proved to be very useful to separate solids from gases if particles are more than 5 µm. Discuss why?

d. (-200) mesh particles are not responsive in gravity separation process. Discuss one suitable method of separation of them with schematic representation of the method.

e. Describe the working principle of air-lift pump.

OR

For a given compression ratio, work-done required in isothermal compressor is less than adiabatic compressor. Explain.

10+2+5+4+4