Q. Code:829151

Reg. No. | | | | | | | | | | | | | |

M.E. / M. TECH.DEGREE EXAMINATIONS, MAY 2024

Second Semester

CL22203 – CHEMICAL PROCESS DESIGN

(Chemical Engineering)

(Regulation 2022)

TIME:3 HOURS **MAX. MARKS: 100**

COURSE OUTCOMES	STATEMENT	RBT LEVEL
CO 1	Impart knowledge on design information and data and Outline the essentials of fluid movers and related items.	**4**
CO 2	Instruct the basics of process design of heat transfer equipment.	**4**
CO 3	Apply the knowledge on heat transfer equipments.	**4**
CO 4	Identify the methods of process design of separation columns.	**5**
CO 5	Pertain the mechanical design of Pressure vessels	**5**

PART- A (20x2=40Marks)

(Answer all Questions)

		CO	RBT LEVEL
1.	Calculate the density of Methanol and water at 40°C, composition 40% (Wt/Wt) Methanol. density of Methanol = 791.2 kg/m^3 and density of Water = 998.2 kg/m^3	**1**	**3**
2.	Infer the ways to specify the dimensions of pipe.	**1**	**2**
3.	Estimate the safe working pressure for a 4 in. (100 mm) dia., schedule 40 pipe, carbon steel, butt welded, working temperature 100°C. The safe working stress for butt welded steel pipe up to 120°C is 6000 lb/in^2 (41.4 N/mm^2).	**1**	**3**
4.	List the three undesirable effects of cavitation in pumps.	**1**	**2**
5.	List down few energy conservation opportunities in pumping system.	**2**	**2**
6.	Discuss direct contact heat exchanger with examples.	**2**	**2**
7.	Infer the types of Baffles used in shell and tube exchangers.	**2**	**2**
8.	Highlight the parameters considered for the selection of best type of reboiler or vaporizer for a given duty.	**2**	**3**
9.	Mention the phenomena of boiling point elevation (BPE) and its dependent factors.	**3**	**2**
10.	Mention the significance of steam consumption.	**3**	**2**
11.	List the factors to be considered for Evaporator design.	**3**	**2**
12.	Highlight the pros and cons of Short-Tube Vertical Evaporators.	**3**	**2**
13.	Cite the assumptions of Mccabe -Thiele Design Method.	**4**	**2**
14.	Mention the characteristics of packing materials used in the process industries.	**4**	**2**
15.	State the significance of Height Equivalent to Theoretical Plate (HETP) in packed column.	**4**	**2**

16.	Mention the advantages of Fluidised bed drier.	**4**		**2**
17.	Mention the various standard codes for Pressure vessel.	**5**		**3**
18.	How minimum wall thickness is calculated for hydrostatic pressure vessel.	**5**		**3**
19.	Find the thickness of pressure vessel head if the crown radius is reduced to half with the doubled design stress.	**5**		**3**
20.	List the significant data needed by the specialist engineer for the pressure vessel design.	**5**		**3**

PART- B (5x 10=50Marks)

		Marks	CO	RBT LEVEL
21.(a)	A pipeline connecting two tanks contains four standard elbows, a plug valve that is fully open and a gate valve that is half open. The line is commercial steel pipe, 25 mm internal diameter, length 120 m. The properties of the fluid are: viscosity 0.99 $mNm^{-2}s$, density 998 kg/m^3. Estimate the total pressure drop due to friction when the flow rate is 3500 kg/h.	**(10)**	**1**	**4**
	(OR)			
(b)	A tanker carrying toluene is unloaded, using the ship's pumps, to an on-shore storage tank. The pipeline is 225 mm internal diameter and 900 m long. Miscellaneous losses due to fittings, valves, etc., amount to 600 equivalent pipe diameters. The maximum liquid level in the storage tank is 30 m above the lowest level in the ship's tanks. The ship's tanks are nitrogen blanketed and maintained at a pressure of 1.05 bar. The storage tank has a floating roof, which exerts a pressure of 1.1 bar on the liquid. The ship must unload 1000 ton within 5 hours to avoid demurrage charges. Estimate the power required by the pump. Take the pump efficiency as 70 per cent. Physical properties of toluene: density 874 kg/m^3, viscosity 0.62 mNm^{-2} s.	**(10)**	**1**	**4**
22.(a)	Assess the overall heat transfer coefficient of a shell and Tube heat exchanger to sub-cool condensate from a methanol condenser from 95°C to 40°C. Flow-rate of methanol 100,000 kg/h. Brackish water will be used as the coolant, with a temperature rise from 25° C to 40°C. Thermal conductivity of cupro-nickel alloys D 50 W/m°C. Take the fouling coefficients: methanol (light organic) 5000 $W/m^2°C$ brackish water (sea water), 3000 $W/m^2°C$	**(10)**	**2**	**4**
	(OR)			
(b)	Estimate the heat-transfer coefficient for steam condensing on the outside, and on the inside, of a 25 mm o.d., 21 mm i.d. vertical tube 3.66 m long. The steam condensate rate is 0.015 kg/s per tube and condensation takes place at 3 bar. The steam will flow down the tube. Saturation temperature = 133.5°C	**(10)**	**2**	**4**

$\rho_L = 931$ kg/m^3
$\rho_v = 1.65$ kg/m^3
$k_L = 0.688$ W/m°C
$\mu_L = 0.21$ mNs/m^2
$Pr_c = 1.27$

23.(a) An aqueous solution of a solute is concentrated from 5% to 20% (mass basis) in a single effect short-tube evaporator. The feed enters the evaporator at a rate of 10kg/s and at a temperature of 300 K. steam is available at a saturation pressure of 1.3 bar. The pressure in the vapor space of the evaporator is 0.13 bar and the corresponding saturation temperature is 320K. If the overall heat transfer coefficient is 5000 W/m^{2}K, calculate steam economy and heat transfer surface area required. **(10) 3 4**

	Enthalpy (kJ/kg)	Heat of Vaporization (kJ/kg)
Saturated steam (1.3 bar, 380K)		2000
Saturated steam (0.13 bar, 320K)	2200	
Feed (5%, 300K)	80	
Concentrated Liquid (20%, 325K) B.P.E is 5K	400	

(OR)

(b) A triple effect forward feed evaporator is used to concentrate a liquid which has marginal elevation in boiling point. The temperature of the stream to the first effect is 105°C, and the boiling point of the solution within third effect is 45°C. **(10) 3 4**

The overall heat transfer coefficients are,
2,200 W/m^2 °C: in the I-effect,
1,800 W/m^2 °C: in the II-effect,
1,500 W/m^2 °C: in the III-effect.
Find out at what temperatures the fluid boils in the I and II effects.

24.(a) Coal gas is to be free of its light oil by scrubbing wash oil as an absorbent and the light oil is recovered. Absorber gas is to 0.25m^3/sec at 25°C.Total pressure of the system is 803mmHg containing 2% (volume) of light oil vapors. The light oil is entirely assumed to be benzene and 95% removal is recovered. The wash oil enters at 25°C containing 0.005 mole fraction and has an average molecular weight of 260.An oil circulation rate is 1.5 times of the minimum is to be used. The temp will be constant at 26°C and the vapor pressure of benzene C_6H_6 is 100mmHg. Elucidate the number of plates required. **(10) 4 4**

(OR)

(b) A continuous fractionating column is to designed to separate 30000 kg/hr of a mixture of 40% benzene and 60% toluene into an overhead product containing 97% benzene and a bottom product contains 98% toluene **(10) 4 4**

percentage are by weight. A Reflux ratio (R_D) of 3.5 moles to 1 mole of product is to be used. The molal latent heat of benzene and toluene are 7360 and 7960 cal /g mol respectively Benzene and Toluene from a ideal system with a relative volatility of about 2.5, the feed has a boiling point of 95°C at a pressure of 1 atm.

I. Assess the moles of overhead product and bottom product per hour.

II. Determine the number of ideal plates if the feed is at its boiling point.

x	0	0.2	0.4	0.6	0.8	1
y	0	0.384	0.625	0.789	0.909	1

25.(a) A vertical vessel with a cylindrical shell is covered with a torispherical head at the bottom and hemispherical at the top. The internal diameter of vessel is 2.55 m and its wall thickness is 0.022 m. The effective diameter of flat head is 4.1 m, length 1.8 m, breadth 0.58 m & its thickness is 78 mm. The vessel is filled with its 85% of its total capacity with a liquid having a specific gravity of 0.87. Determine the total weight of the vessel and the principal stresses in the cylindrical section with the length of 12 m. Permissible stress of the material is 1232 kg/m^2.
The vessel is of Class I, II & III and Compare the values and write the inference with suggestions. The density of the material is 8202 kg/m^3. The radius of torispherical head are (80 -25) and (90 -35). **(10) 5 4**

(OR)

(b) Estimate and analyse the different stresses and radial deflection due to the internal pressure and external pressure for the given data. Assume the relevant data. Inside and outside diameter of the vessel are 1.95 m and 2.18 m. External and Internal Pressure on the vessel are 1200 kg/m^2 and 600 kg/m^2. Poisson's ratio is 0.65. Give inferences if deficit in pressure vessel design. **(10) 5 4**

PART- C (1x 10=10Marks)

(Q.No.26 is compulsory)

		Marks	CO	RBT LEVEL
26.	A mixture at the rate of 400 kmole/hr is to be separated by distillation. The feed contains 20 mole% butane, 25 mole% heptane, 45 mole% n-pentane and the balance octane. It is desired to obtain a distillate stream containing not more than 6mole % heptane and a bottoms stream containing not more than 3 mole% n-pentane. Design a multicomponent distillation column and give your suggestions to increase the mole fraction of light key.	**(10)**	**4**	**5**

Component	α, TOP	α, BOTTOM
butane	2.46	3.18
n-pentane	1.532	2.645
heptane	1.00	1.00
octane	0.86	0.63

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