U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

October 2024 Supplementary Examinations

Programme: B.E. **Semester: VI**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 22CH6PCPED **Max Marks: 100**
Course: Process Equipment Design

Instructions:

1. Answer Unit I and Unit IV are compulsory. Answer any ONE full question from choosing Unit II and Unit III.
2. Missing data, if any, may be suitably assumed & stated.
3. Perry's Chemical Engineers Handbook, IS 4503 and IS 2825 Unfired Pressure Vessel Codebooks are permitted to use.

			CO	*PO*	**Marks**
		UNIT – I			
1	a)	Discuss the general design procedure adopted in chemical equipment design.	*CO3*	*PO4*	**08**
	b)	How are chemical process equipment classified? Explain.	*CO3*	*PO4*	**06**
	c)	With design equations, explain the various vessel enclosures used in the chemical industry.	*CO3*	*PO4*	**06**
		UNIT – II			
2		A 42° API kerosene leaves the bottom of a distillation column at a rate of 19,900 kg/h at 200°C and it is to be cooled to 93 °C by 67,650 kg/h of a 34° API crude coming from storage at 38 °C and heated to 77 °C. A pressure drop of 70 kPa is permissible for both the streams and a combined dirt factor of $3.5\times10^{-4}\ \frac{m^2K}{W}$. Available for this service with 21¼ inches ID Shell and Tube Heat Exchanger (STHE) having 158 numbers of one inch, 13 BWG tubes of 16 feet long, laid out on 1¼ inches square pitch. The bundle is arranged for 4 passes and baffles are spread 5 inches apart. Design the heat exchanger. Data:			

Properties	*Density* ρ (kg/m^3)	*Specific Heat* C_P (kJ/kg K)	*Viscosity* μ (cP)	*Thermal Conductivity* k (W/m K)
Kerosene	780	2.48	0.4	0.132
Crude	824	2.06	3.6	0.133

	a)	Estimate the heat load and corrected LMTD for the given temperatures. Also, find the dirt overall heat transfer coefficient of the available STHE.	*CO2*	*PO4*	**20**
	b)	Find the clean overall heat transfer coefficient. Is the available STHE suitable for the given heat load?	*CO2*	*PO4*	**20**
	c)	Estimate the shell thickness and shell diameter.	*CO2*	*PO4*	**07**
	d)	Determine the pressure drops across shell and tube side. Comment on the suitability of the exchanger for the operation.	*CO2*	*PO4*	**08**
	e)	Draw the sketch of sectional front view of the STHE.	*CO4*	*PO2*	**05**

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
Revealing of identification, appeal to evaluator will be treated as malpractice.

			UNIT - III			
	3		A crystallizer industry is planning to buy an evaporator for their new product. For this purpose, a single-effect evaporator is required to concentrate 36,000 kg/h of a solution from 10% to 50% solids. Steam is available at 205 kN/m^2 and the evaporation takes place at 13.5 kN/m^2. The feed to the evaporator is at 294 K. The overall heat transfer coefficient is 3.27 kW/m^{2}K. The specific heats of 10% to 50% solutions are 3.76 and 3.14 kJ/kg, respectively. The height of the evaporator body above the calandria may be at least 3m to minimize entrainment. The calandria has vertical tubes of 5 cm ID, with a thickness of 2.5 mm, and 2 m height spaced on a triangular pitch of 6.25 cm. The cross-sectional area of the down-comer should be at least 75% of the total cross-sectional area of all the tubes to ensure rapid circulation. For the construction of the evaporator, mild steel is used, which has an allowable stress of 9.5 kg/mm^2. Constant k may be assumed as 2.857 for the flange design. Design the evaporator.			
		a	Determine the heat load, amount of steam required, and economy of the evaporator.	*CO1*	*PO2*	**20**
		b	Estimate the number of tubes, the diameter of calandria, the vapor drum of the evaporator, and the total height of the evaporator.	*CO2*	*PO4*	**15**
		c	Determine the thickness of calandria, vapour drum, and flange.	*CO2*	*PO4*	**15**
		d	Estimate the diameter of any one nozzles.	*CO2*	*PO4*	**05**
		e	Draw the schematic diagram of the evaporator designed.	*CO4*	*PO2*	**05**
			UNIT – IV			
	4	a	A pressure vessel of internal diameter 1600 mm operates at 5 kg/cm^2. The vessel is to be provided with a nozzle of 100 mm internal diameter. The nozzle does not project inside the shell. The permissible stress of the material is 1020 kg/cm^2. Estimate the reinforcement required for the nozzle. Assume the vessel is spot radiographed and material of construction is stainless steel.	*CO3*	*PO4*	**10**
		b	A pressure vessel is to operate at 7.5 kg$_f$/cm^2 pressure and a temperature of 100°C. Calculate the shell thickness and thickness of the head for the following cases: i. Hemispherical head ii. Tori spherical head (100-08) iii. Elliptical with k = 2.0 Data: • Length of the vessel = 2000 mm, • Mean diameter of the vessel = 1800 mm, • The vessel is spot radiographed, • MOC is SS, and • Allowable stress = 1400 kg/cm^2.	*CO3*	*PO4*	**10**

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