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Sub: HTED(BTCHE606)

1) A double-effect evaporator is employed to concentrate 10,000 kg/h of caustic soda solution from 9% to 47% by wt. NaOH. For this purpose, backward feed arrangement is used. The feed enters the evaporator at 309 K (36° C). Process steam at 686.616 kPa. is available and in the second effect a vacuum of 86.66 kPa is maintained. Design a suitable forced circulation system with equal heating surface in both the effects. Calculate the steam consumption and evaporation in each effect. Neglect boiling point rise. The overall heat transfer coefficients in the first and second effects are 2326 and 1744.5 W/(m2.K) respectively. Take a specific heat value of 3.77 kJ/(kg K) for all caustic streams.
2) A triple-effect evaporator is concentrating a solution that has no appreciable boiling point elevation. The temperature of steam to the first effect is 381.3 K (108.3° C) and boiling point of the solution in the last effect is 324.7 K (51.7° C). The overall heat transfer coefficients in the first, second and third-effect are 2800, 2200 and 1100 W/(m2.K) respectively. At what temperatures will the solution boil in the first and second effects?
3) A saturated solution of MgSO, at 353 K (80° C) is cooled to 303 K (30° C) in a crystallizer. During cooling, 4 % solution is lost by evaporation of water. Estimate the quantity of the original saturated solution to be fed to the crystallizer per 1000 kg of MgSO4 7 H_2O crystals.
   Data: Solubility of MgSO4 at 303 K (30° C) = 40.8 kg/100 kg water Solubility of MgSO4 at 353 K (80° C) = 64.2 kg/100 kg water At. Wt.: Mg= 24, S = 32, O = 16 , and H = 1.0
4) A single effect evaporator is fed with 5000 kg/h of solution containing 1 % solute by weight. Feed temperature is 303 K (30° C) and is to be concentrated to a solution of 2 % solute by weight. The evaporation is at atmospheric pressure (101.325 kPa) and area of evaporator is 69 m^2. Saturated steam is supplied at 143.3 kPa as a heating medium. Calculate steam economy and overall heat transfer coefficient.
   Data:
   Enthalpy of feed at 303 K = 125.79 kJ/kg
   Enthalpy of vapour at 101.325 kPa = 2676.1 kJ/kg
   Enthalpy of saturated steam at 143.3 kPa = 2691.5 kJ/kg
   Saturation temperature of steam= 383 K (110° C)
   Boiling point of saturation= 373 K
   Enthalpy of product = 419.04 kJ/kg
   Enthalpy of saturated water at 383 K = 461.30 kJ/kg

5) A single effect evaporator is to concentrate 20000 kg/h of a solution having a concentration of 5% salt to a concentration of 20 % salt by weight. Steam is fed to the evaporator at a pressure corresponding to the saturation temperature of 399 K (126° C). The evaporator is

operating at atmospheric pressure and boiling point rise is 7 K. Calculate the heat load and steam economy.

Data: Feed temperature = 298 K (25° C)

Specific heat of feed = 4.0 kJ/(kg K)

Latent heat of condensation of steam at 399 K = 2185 kJ/kg

Latent heat of vaporization of water at 373 K = 2257 kJ/kg

6) Define the following terms:

(i) evaporation (ii) boiling point elevation (iii) capacity of evaporator and (iv) economy of an evaporator.

7) State why the economy of single effect evaporator is less than one?

8)State the method of increasing the economy of an evaporator.

9)What do you mean by multiple effect evaporation system?

10) What do you mean by double effect evaporator?

11) State the method of feeding multiple effect evaporation system.

12) Compare forward feed arrangement with backward feed arrangement in case of multiple effect evaporation system.

13) State the advantages of forced circulation evaporators and its application.

14) Write construction with neat sketch of standard vertical tube evaporator.

15) Draw the neat diagrams of forward feed arrangement and backward feed arrangement for feeding multiple effect evaporation system.

16) Mention the common examples of evaporation operation.

17) Draw neat sketch of long tube evaporator and explain briefly its construction and working.

18) Explain in brief forced circulation evaporator with external horizontal heating surface with reference to its construction and working.

19) Explain in brief vapour recompression with neat sketch.

20) A crystallizer is charged with 7500 kg of an aqueous solution at 377 K (104° C), 29.6% by weight of which is anhydrous sodium sulphate. The solution is cooled. During the cooling operation, 5 % of the initial water is lost by evaporation. As a result, crystals of Na_2SO_4 10 H_2O crystallizes out. If the mother liquor is found to contain 18.3 % by weight anhydrous Na_2SO_4,

calculate the yield of crystals and the quantity of mother liquor. At. Wt.: Na= 23, S=32, O=16, H = 1.

21) Calculate the yield of MgSO, 7H2O crystals when 1000 kg saturated solution of MgSO4 at 353 K is cooled to 303 K assuming 10% of water is lost by evaporation during cooling.

Data: Solubility of MgSO4 at 353 K = 64.2 kg/100 kg water Solubility of MgSO4 at 303 K = 40.8 kg/100 kg water

Mol. Wt. of MgSO4 = 120, Mol. Wt. of MgSO47 H_2O=246

22) A solution of sodium nitrate in water contains 48% NaNO3 by weight at 313 K temperature. Calculate the percentage yield of NaNO3 crystals that may be obtained when temperature is reduced to 283 K. Solubility of NaNO3 at 283 K is 80.18 kg/100 kg water.

23) Explain in brief solubility curves.

24) State various methods of generating supersaturation.

25) Explain briefly the classification of crystallisers.

26) Discuss in brief crystal formation.

27) Explain in brief with neat sketch Swenson-Walker crystallizer.

28) Write in brief on Oslo-cooling crystallizer.

29) Write a short note on agitated tank crystallizer.

30) With neat sketch explain construction and working of vacuum crystallizer.

31) Define the following terms:

(a) condenser (b) cooler (c) vaporizer (d) heater (e) reboiler (f) chiller

32) Give the classification of shell and tube heat exchanger.

33) Write in brief on double pipe heat exchanger.

34) Draw neat sketch of fixed tube sheet heat exchanger and label its parts.

35) Write in brief on plate heat exchanger.

36) Write in brief on scrapped surface heat exchanger.

37) Draw neat sketch of kettle reboiler and explain its construction.

38) Draw neat sketch of floating heat exchanger and explain its construction.

39) What do you mean by term fins. Draw neat sketches of longitudinal and transverse fins.

40)Write in brief in finned tube heat exchanger.

41) Draw neat sketch of U-tube heat-exchanger and explain briefly its construction.

42) Draw the neat sketch of kettle reboiler and explain in brief its construction.

43) Draw the neat sketch of 1-2 shell and tube heat exchanger and label its parts.

44) State the advantages of floating head heat exchanger.

45) State the advantages of double pipe heat-exchanger and its drawbacks.

46) In a double pipe counter current flow heat exchanger, 10000 kg/h of an oil having a specific heat of 2095 J/(kg K) is cooled from 353 K (80° C) to 323 K (50° C) by 8000 kg/h of water entering at 298 K (25° C). Calculate the heat exchanger area for an overall heat transfer coefficient of 300 W/(m2.K). Take Cp for water as 4180 J/(kg K).

47) Hot oil at a rate of 1 2 kg/s [Cp =2083 J/(kg-K)] flows through double pipe heat exchanger. It enters at 633 K (360° C) and leaves at 573 K (300° C). The cold fluid enters at 303 K (30° C) and leaves at 400 K (127° C). If the overall heat transfer coefficient is 500 W/(m2.K), calculate the heat transfer area for (i) parallel flow and (ii) countercurrent flow.

48) It is required to design a shell and tube heat exchanger for heating 9000 kg/hr of water from 15°C to 88°C by hot engine oil (Cp=2.36 kJ/kg-K) flowing through the shell of the heat exchanger. The o-makes a single pass, entering at 150°C and leaving at 95°C with an average heat transfer coefficient of 400 W/m-K, the water flow through 10 thin-walled tubes of 25mm diameter with each tube making 8 passes through the shell. The heat transfer efficient on the water side is 3000 W/m²-K. Find the length of the tube required for the heat exchanger. [10]

49) Write short notes on any five:

(a) Codes and Standards. (b) Design Pressure, Design Temperature and Weld Efficiency. (c) Factors to be considered in the design of a pressure vessel. (d) Types of Agitators and their applications. (e) Types of Supports. (f) Types of Storage Tanks.

55) (a) Consider an agitated vessel where the contents are mixed using an agitator. Provide a detailed design procedure for the design of the system considering the following items in the design:

(i) Agitator shaft. (i) Blade assembly (iii) Stuffing box (iv) Flange coupling.

(b) Draw a neat and proportional drawing of the above system naming the various parts.