Mass Transfer – I (CH21202)

Tutorial Sheet No.: MT-I/NCP/2024/2

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1. Ammonia is to be removed from an ammonia-air mixture by water scrubbing in a 0.786 m diameter tower packed with 25 mm Raschig rings. The gas mixture is available at the rate of 600 m^3/h (at 25^oC and 1 atm) with 10% ammonia by volume. Pure water will be used as solvent at a rate twice the minimum. Film coefficients are $k_y a$ = 150 kmol/m^3 h Δy and $k_x a$ = 325 kmol/ m^3 h Δx. The equilibrium relation may be expressed $y^* = 1.02\ x/(1 - x)$. Calculate the depth of the packing required for 98% removal of ammonia.

[Ans. 3.2 m]

2. Benzene is to be removed from coke oven gas by scrubbing into a nonvolatile hydrocarbon oil in a 2.0 m diameter tower packed with 25 mm Berl saddles. The gas mixture is available at the rate of 100 kmol/h with 6% benzene by volume. Calculate the depth of the packing required to reduce the benzene content to 0.2% by volume. The scrubbing liquid, which is recycled from a stripper, contains 0.1 mol % benzene. The gas-liquid equilibrium may be expressed as $y^* = 0.65\ x$ where y^* is the equilibrium mole fraction of benzene in the gas phase at composition x mole fraction benzene in the oil. The oil rate is 160 kmol/h and K_ya is given as 68 kmol/m^3 h (Δy^*).

[Ans. 2.7 m]

3. Acetone is being absorbed by water in a packed tower having a cross-sectional area of 0.186 m^2 at 20^oC and 1 atm pressure. The inlet air contains 2.6 mol% acetone and the outlet air contains 0.5 mol% acetone. The gas flow rate is 14.0 kmol/h. The pure water flow rate 820 kg/h. Film coefficients for the given flows in the tower are $k_y a$ = 0.0378 kmol/m^3 s Δy and $k_x a$ = 0.0616 kmol/ m^3 s Δx. The equilibrium relation may be expressed as $y = 1.186\ x$. Determine the height of the tower.

[Ans. 1.96 m]

4. A relatively nonvolatile hydrocarbon oil contains 2.5 mol% propane and is being stripped by direct superheated steam in a packed tower having a cross-sectional area of 0.86 m^2 to reduce the propane content to 0.2%. 25 kmol/h of direct steam is used for 250 kmol/h of entering liquid. The vapour-liquid equilibrium may be represented by $y = 25\ x$, where y is the mole fraction of propane in the steam and x is the mole fraction of propane in the oil. Steam can be considered as inert gas and will not condense. Film coefficients for the given flows in the tower are $k_y a$ = 0.04 kmol/m^3 s Δy and $k_x a$ = 0.06 kmol/ m^3 s Δx. Determine the height of the tower for the stripping operation.

[Ans. 4.88m]

5. Ammonia is to be removed from an ammonia-air mixture by water scrubbing in a 0.30 m diameter tower packed with 25 mm Berl saddles. The gas mixture is available at the rate of 6.0 kmol/h with 3% ammonia by volume. Calculate the depth of the packing required to reduce the ammonia content to 0.1% by volume. Laboratory data show that the Henry's law expression for solubility may be expressed as $y^* = 1.5\ x$ where y^* is the equilibrium mole fraction of ammonia over water at composition x mole fraction ammonia in the liquid. The water rate is 14 kmol/h and K_ya is given as 265 kmol/m^3 h (Δy^*).

[Ans. 2.27m]

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