

一. 多项选择题

1. c 2. c 3. d 4. a.b.c 5. a

二. 填空题

1. 减小, 增大, 增大 (书B86)
2. 增大了气液接触面积, 促使气流分布均匀, 促进了气相的湍流 (P333)
3. 喷射态, 泡沫态, 鼓泡态
4. 1
5. 7.309

三. 简答题 P374-9.1.3000

四. 实验题

1. 略

2. $d_o = 0.016 \text{ m}$ $d_i = (16 - 1.5 \times 2) \times 10^{-3} \text{ m} = 0.013 \text{ m}$

$A_o = \pi d_o L = 0.05024 \text{ m}^2$ $A_i = \pi d_i L = 0.04082 \text{ m}^2$

$W_c = \rho \cdot V = 1000 \times \frac{1.5}{3600} \text{ kg/s} = 0.41667 \text{ kg/s}$

$T_{w1} = t_{w1} = 85.3^\circ\text{C}$ $T_{w2} = t_{w2} = 78.5$

$(T - T_w)_m = \frac{(T_1 - T_{w2}) - (T_2 - T_{w1})}{\ln \frac{T_1 - T_{w2}}{T_2 - T_{w1}}} = 20.049^\circ\text{C}$

$(t_w - t)_m = \frac{(t_{w1} - t_1) - (t_{w2} - t_2)}{\ln \frac{t_{w1} - t_1}{t_{w2} - t_2}} = 61.504^\circ\text{C}$

由公式 $W_c c_p (t_2 - t_1) = \alpha_o A_o (T - T_w)_m = \alpha_i A_i (t_w - t)_m$

计算得 $\alpha_o = 2302.4 \text{ W/(m}^2 \cdot \text{K)}$

$\alpha_i = 9237.6 \text{ W/(m}^2 \cdot \text{K)}$

3. 当水蒸汽中含有 1% 的不凝性气体, 给热系数下降 60% 左右。

五、计算题

1. 解(1) 设加入空气后, A容器上部空间的压力为 P_A' , 体积为 V'

原A容器上部空间体积为 V , 则 $V = h \cdot 1 \text{ m}^3 = 0.5 \text{ m}^3$

再设平衡后A容器液面下降高度为 R_A , 则其下降体积为 $\Delta V = 1 \cdot R_A = R_A \text{ m}^3$

$V' = V + \Delta V = (0.5 + R_A) \text{ m}^3$, 同理B管上升液体体积为 ΔV

上升液面高度 $R_B = \frac{\Delta V}{0.2} = \frac{R_A}{0.2} = 5R_A \text{ m}$, $P_A = 9.81 \times 10^4 \text{ Pa}$

由 $PV = nRT$ 得: $\frac{P_A V}{P_A' V'} = \frac{n_1}{n_2} = \frac{1}{2}$

$$\Rightarrow P_A' = \frac{2P_A \cdot V}{V'} = \frac{9.81 \times 10^4}{0.5 + R_A} \text{ Pa}$$

平衡后, A、B容器底部压力相等, 且B上方接大气压, 由静力学平衡得:

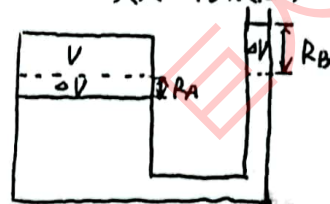
$$P_A' + \rho g(H_1 - R_A) = P_0 + \rho g(H_1 + R_B)$$

解得 $R_A = 0.3175 \text{ m}$

则平衡后相对于底部, B液面高度为 $(H_1 + R_B) = 1.3175 \text{ m}$

$$(2). \text{ 由 (1) } P_A' = \frac{9.81 \times 10^4}{0.5 + R_A} = 1.2 \times 10^5 \text{ Pa}$$

附图: (虚线—原液面
实线—现液面)



2. 解(1) 在1-2截面列伯努利方程:

$$\frac{u_1^2}{2g} + \frac{P_1}{\rho g} + z_1 + H_e = \frac{u_2^2}{2g} + \frac{P_2}{\rho g} + z_2 + \sum H_{f,1-2}$$

由题意 $u_1 = u_2 = 0$, $P_1 = P_2$ (表压) $= 0$, $z_1 = 0$, $z_2 = 18 \text{ m}$, $\sum H_{f,1-2} = (2 + 4) \text{ m H}_2\text{O}$

则 $H_e = 24 \text{ m H}_2\text{O}$

$$N_a = \frac{N_e}{\eta} = \frac{\rho V g H_e}{\eta} = \frac{1000 \times \frac{30}{3600} \times 9.81 \times 24}{0.6} = 3270 \text{ W}$$

$$(2). P_1 = P_0 = 9 \text{ m H}_2\text{O} = 88257.5 \text{ Pa}$$

$$\begin{aligned} H_{g, \max} &= \frac{P_0 - P_v}{\rho g} - \Delta h_{\text{fr}} - \sum H_f \\ &= \frac{88257.5 - 1705.16}{1000 \times 9.81} - 3.2 - 2 \\ &= 3.623 \text{ m} > 2 \text{ m} \end{aligned}$$

故安装高度合适

3. 解: (1) 沉降速度 $u_t = \frac{g d_p^2 \cdot (\rho_s - \rho)}{18 \mu}$

由题意 $\frac{u_0}{u_w} = \frac{\rho_s - \rho_0}{\rho_s - \rho_w} \cdot \frac{\mu_w}{\mu_0} = 88.4 \quad \text{--- ①}$

$\frac{\rho_s V g - \rho_0 V g}{\rho_s V g - \rho_w V g} = \frac{\rho_s - \rho_0}{\rho_s - \rho_w} = 1.6 \Rightarrow \text{解得 } \rho_s = 2659.8667 \text{ kg/m}^3$

(2). 由(1)中①式得 $u_0 = 0.0181 \text{ m Pa} \cdot \text{s}$

(3). $u_0 = \frac{g d_p^2 \cdot (\rho_s - \rho_0)}{18 \mu_0} = \frac{9.81 \times (30 \times 10^{-6})^2 \times (2659.8667 - 1.2)}{18 \times 0.0181 \times 10^{-3}} \text{ m/s} = 0.072 \text{ m/s}$

4. 解: (1). 由 $H = H_{OG} \cdot N_{OG}$ 分析, H, H_{OG} 不变, 则 N_{OG} 维持不变

$A = \frac{mG}{L} = 0.6667, \quad \eta = \frac{y_1 - y_2}{y_1} \Rightarrow y_2 = 0.001$

$N_{OG} = \frac{1}{1-A} \ln \left[(1-A) \cdot \frac{y_1 - m x_2}{y_2 - m x_2} + \frac{1}{A} \right] = 5.3756$

当 $x_2 \rightarrow x_2'$ 后, $y_2 \rightarrow y_2', A \cdot N_{OG}$ 维持不变

$N_{OG} = \frac{1}{1-A} \cdot \ln \left[(1-A) \cdot \frac{y_1 - m x_2'}{y_2' - m x_2'} + \frac{1}{A} \right] = 5.3756$

解得 $y_2' = 0.00128$

(2). 由物料衡算 $\frac{L}{G} = \frac{y_1 - y_2'}{x_1' - x_2'} = 3$ 解得 $x_1' = 0.00326$

5. 解: $\eta_{\text{苯}} = \frac{D x_D}{F x_F} = 0.97$

$\eta_{\text{甲苯}} = \frac{W(1-x_W)}{F(1-x_F)} = 0.95$

再结合 $\begin{cases} F = D + W \\ F x_F = D x_D + W x_W \end{cases}$

解得 $D = 62.7 \text{ kmol/h}, W = 87.3 \text{ kmol/h}$
 $x_D = 0.9282, x_W = 0.02062$

(1). ①. 精馏段操作线 $y = \frac{R}{R+1} x + \frac{x_D}{R+1} = 0.8x + 0.18564$

提馏段操作线 $L' = L + qF = RD = 250.8 \text{ kmol/h}$ (饱和蒸汽进料, $q=0$)

$V' = V - (1-q)F = (R+1)D - F = 163.5 \text{ kmol/h}$

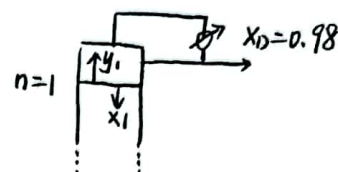
$y = \frac{L'}{V'} x - \frac{W}{V'} x_W = 1.5291x - 0.011$

②. 饱和蒸汽进料 $y_e = x_f = 0.4$, 由相平衡方程 $y = \frac{\alpha x}{1 + (\alpha - 1)x}$ 反解 $x_e = 0.2125$

$$\text{则 } R_{\min} = \frac{x_D - y_e}{y_e - x_e} = 2.8171$$

$$\text{故 } R/R_{\min} = 1.42$$

(2) $E_{mv,1} = \frac{y_1 - y_2}{y_1^* - y_2}$, 全凝器 $y_1 = x_D = 0.98$



全回流时操作线方程 $y_{n+1} = x_n$, 即 $y_2 = x_1$

$$y_1^* = \frac{\alpha x_1}{1 + (\alpha - 1)x_1} = \frac{2.47 y_2}{1 + 1.47 y_2}$$

$$\text{代入 } E_{mv,1} = 0.6 \text{ 解得 } y_2 = 0.969$$

b. 解: $x_1 \xrightarrow[T_1]{\text{恒}} x_0 \xrightarrow[T_2]{\text{降}} x_2$

$$x_1 = \frac{w_1}{1 - w_1} = 0.4006$$

$$x_2 = \frac{w_2}{1 - w_2} = 0.0799$$

$$T_1 = \frac{G_C (x_1 - x_0)}{A u_0}$$

$$T_2 = \frac{G_C (x_0 - x^*)}{A u_0} \ln \frac{x_0 - x^*}{x_2 - x^*}$$

$$\begin{cases} T_1 / T_2 = 2.2465 \\ T_1 + T_2 = 7 \end{cases}$$

$$\text{解得 } T_1 = 4.8438 \text{ h}$$

$$T_2 = 2.1562 \text{ h}$$

$$x_1 \xrightarrow[T_1]{\text{恒}} x_0 \xrightarrow[T_2']{\text{降}} x_2'$$

$$x_2' = \frac{w_2'}{1 - w_2'} = 0.0504$$

$$T_1 = \frac{G_C (x_1 - x_0)}{A u_0}$$

$$T_2' = \frac{G_C (x_0 - x^*)}{A u_0} \ln \frac{x_0 - x^*}{x_2' - x^*}$$

$$\frac{T_2}{T_2'} = 0.4299 \Rightarrow T_2' = 5.0156 \text{ h}$$

$$\text{则 } T' = T_1 + T_2' = 9.8594 \text{ h}$$