

一、选择题

1. C
2. C
3. D
4. D
5. B

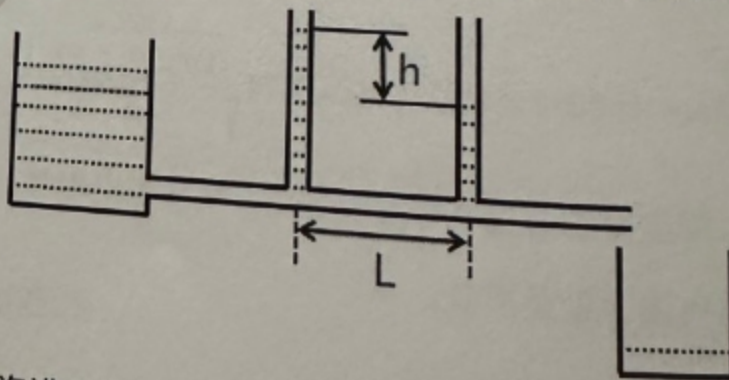
二、填空题

1. 大; 小
2. 增大; 不变; 减小
3. 长度; 宽度; 高度
4. 筛板塔; 泡罩塔; 浮阀塔
5. 溶质 A; 溶剂 B; 溶剂 S

三、思考题

1. 答: (1) 层流: 流体作有秩序的、层次分明的流动, 流速层间没有质点扩散现象发生, 流体内部没有漩涡, 同一平截面上点速度沿直径方向呈抛物线规律变化。(2) 层流时阻力损失与: 流体黏度、密度、流速、管长、管径。(3) 哈根-泊肃叶公式:

$$\sum h_f = \frac{p_{m,1} - p_{m,2}}{\rho} = \frac{32\mu ul}{\rho d^2}$$
, 测量时可实际如图所示的实验装置, 容器中的待测液体 (设已知其密度) 通过毛细管流入烧杯。设法测出毛细管两侧的压强差 ($P_1 - P_2$) 如图中的长度 L , 毛细管的内径和流出毛细管的流量, 则可测量出此液体的黏度。



2. 答: (1) 加热蒸汽进口在 A, 出口在 B; (2) 降低污垢热阻, 增大流体流速, 增大湍动流体湍动程度; (3) 冷却水进口在 D, 出口在 C。

6. (1) 已知 $\varphi_0 = 0.6$, $t_0 = 30^\circ\text{C}$, $P_{t0} = 4.25\text{kPa}$, $w_1 = 0.2$, $w_2 = 0.02$

$$H_0 = 0.622 \frac{\varphi_0 \times P_{t0}}{P - \varphi_0 P_{t0}} = 0.0161$$

由于空气经过预热器是等湿过程, 即 $H_0 = H_1$

$$G_c = G_1(1 - w_1) = 400\text{kg/h}$$

$$X_1 = \frac{w_1}{1 - w_1} = 0.25, X_2 = \frac{w_2}{1 - w_2} = 0.0204$$

$$L = \frac{L}{1 + H_0} = 3936.62\text{kg/h}$$

由物料衡算 $L(H_2 - H_1) = G_c(X_1 - X_2) \Rightarrow H_2 = 0.03943\text{kg水气/kg绝干气}$

(2) 由于干燥过程为理想过程, 即为等焓过程 $I_1 = I_2$

$$I_1 = (1.01 + 1.88H_1)t_1 + 2500H_1$$

$$I_2 = (1.01 + 1.88H_2)t_2 + 2500H_2$$

$$\text{解得 } t_1 = 97.75^\circ\text{C}$$

$$(3) Q_p = L(I_1 - I_0) = L(1.01 + 1.88H_0)(t_1 - t_0) = 277445.7\text{kJ/h}$$

2024 年

$$1. (1) u = \frac{V}{A} = \frac{90}{\frac{3.14}{4} \times (0.156)^2 \times 3600} = 1.31\text{m/s}$$

$$Z_2 - Z_1 = 50\text{m}, l + \sum le = 1000\text{m}$$

$$n_1 = 2900\text{r/min}, \lambda = 0.025$$

$$\text{管路特性曲线可表达为: } H_g = \frac{P_2 - P_1}{\rho g} + Z_2 - Z_1 + 8\lambda \frac{l + \sum le}{\pi^2 g d^5} V^2$$

$$= 50 + 8 \times 0.025 \times \frac{1000}{3.14^2 \times 9.81 \times 0.156^5} V^2$$

$$= 50 + 22380.96V^2 = 50 + 0.00173V^2 (V: \text{m}^3/\text{h})$$

$$\text{管路: } H_e = 50 + 0.00173V^2; \text{ 泵: } H = 124.5 - 0.0044V^2$$

联立解得: $V = 110.242\text{m}^3/\text{h}$, 属于高效区, 则此泵满足

$$(2) Z_1 g + \frac{P_1}{\rho} + \frac{u_1^2}{2} + W_e = Z_2 g + \frac{P_2}{\rho} + \frac{u_2^2}{2} + \sum h_f$$

$$h_f = \lambda \cdot \frac{L}{d} \cdot \frac{u^2}{2} = 0.025 \times \frac{1000}{0.156} \times \frac{1.31^2}{2} = 137.51 \text{ J/kg}$$

$$\Rightarrow We = (Z_2 - Z_1)g + \sum h_f = 50 \times 9.81 + 137.51 = 628.01 \text{ J/kg}$$

$$\eta = \frac{Ne}{Na}, Na = \frac{Ne}{\eta} = \frac{W \times We}{\eta} = \frac{\rho V \times We}{\eta} = \frac{1000 \times 90 \times 628.01}{3600 \times 0.68} = 23088.603 \text{ W}$$

$$2. (1) q^2 = K\tau, \tau = \frac{q^2}{K} = \frac{2^2}{2.5 \times 10^{-3}} = 1.6 \times 10^3 \text{ s}$$

$$(2) K \propto \Delta P_m^{1-s}, \text{当滤饼不可压缩时, } s=0, K \propto \Delta P_m$$

$$\frac{K'}{K} = \frac{\Delta P_m'}{\Delta P_m} = 1.5, \therefore K' = 1.5K = 1.5 \times 2.5 \times 10^{-3} = 3.75 \times 10^{-3}$$

$$q_2^2 = K'\tau, q_2 = \sqrt{3.75 \times 10^{-3} \times 1.6 \times 10^3} = 2.45 \text{ m}^3/\text{m}^2$$

$$(3) \tau_w = \frac{q_w}{K/2(q+q_e)} = \frac{0.5 \times 2 \times (2+2.83)}{2.5 \times 10^{-3}} = 1932 \text{ s}$$

$$3. (1) d_i = 25 - 2.5 \times 2 = 20 \text{ mm} = 0.02 \text{ m}$$

$$Re = \frac{d_i u \rho}{\mu} = \frac{d_i W}{A} = \frac{0.02 \times 8000}{3600 \times 0.785 \times 0.02^2 \times 300} = 2.38 \times 10^4 > 10^4$$

$$Pr = 0.7, \frac{L}{d} = \frac{2}{0.025} = 80$$

$$\alpha = 0.023 \times \frac{\lambda}{d_i} \times Re^{0.8} \times Pr^{0.4} = 0.023 \times \frac{2.85 \times 10^{-2}}{0.02} \times (2.38 \times 10^4)^{0.8} \times 0.7^{0.4} = 90.1 \text{ W}/(\text{m}^2 \cdot ^\circ\text{C})$$

(2) 管壁及两侧污垢的热阻均忽略不计

$$\frac{1}{K} = \frac{1}{\alpha_o} + \frac{d_o}{\alpha_i d_i} = 0.01317, \therefore K_o = 71.6 \text{ W}/(\text{m}^2 \cdot ^\circ\text{C})$$

$$(3) Q = W_c C_{pc} (t_2 - t_1) = \frac{8000}{3600} \times 10^3 \times (85 - 20) = 1.44 \times 10^5 \text{ W}$$

$$\Delta t_m = \frac{(108 - 20) - (108 - 85)}{\ln \frac{108 - 20}{108 - 85}} = 48.4^\circ\text{C}$$

$$\text{提供的 } A_o = n\pi d_o L = 300 \times 3.14 \times 0.025 \times 2 = 47.1 \text{ m}^2$$

$$Q = K_o A_o \Delta t_m, \text{需要 } A_o' = \frac{Q}{K_o \Delta t_m} = \frac{1.44 \times 10^5}{71.6 \times 48.4} = 41.6 \text{ m}^2 < 47.1, \text{ 满足需求}$$

4. $x_F = 0.35, q = 1, R = 6.5, x_D = 0.7, x_W = 0.2, \alpha = 2.5$

(1) 精馏段操作线为: $y_{n+1} = \frac{R}{R+1}x_n + \frac{x_D}{R+1} = 0.867x_n + 0.093$

平衡线方程为: $y_n = \frac{\alpha x}{1 + (\alpha - 1)x} = \frac{2.5x}{1 + 1.5x}$, q 线方程为 $x = x_F = x_q = 0.35$

q 线和平衡线联立: $(x_q, y_q) = (0.35, 0.574)$

$x_0 = y_1 = x_D = 0.7$, 代入相平衡方程, $x_1 = 0.483$, 则 $y_2 = 0.867x_1 + 0.093 = 0.512$

$x_2 = 0.296 < x_q$, \therefore 应在第二块塔板处进料

$y_3 = 0.296 \times 0.863 + 0.093 = 0.348, x_3 = 0.1762 < x_W$, 因此总的理论板数不足 3 块

总的理论板数 $= 2 + \frac{x_2 - x_W}{x_2 - x_3} = 2.801$ 块

(2) $E_T = \frac{N_T}{N} = \frac{2.801}{5} = 56\%$

5. $x_2 = 0, G = 2826 \text{ m}^3/h = \frac{2826}{22.4} \text{ kmol/h} = 126.16 \text{ kmol/h}$

$y_1 = 0.05, A = 0.785 \text{ m}^2, \frac{L}{G} = 1.4 \left(\frac{L}{G} \right)_{\min} = 1.4 \frac{y_1 - y_2}{x_1^* - x_2} = 1.4 \times m \eta = 1.6464$

$\eta = \frac{y_1 - y_2}{y_1} = \frac{0.05 - y_2}{y_1}, y_2 = 0.001$

(1) $G(y_1 - y_2) = L(x_1 - x_2), \therefore x_1 = \frac{G}{L}(y_1 - y_2) = 0.03$

(2) $H_{OG} = \frac{G}{k_y a A} = \frac{126.16}{180 \times 0.785} = 0.893 \text{ m}$

$N_{OG} = \frac{y_1 - y_2}{\Delta y_m} = \frac{y_1 - y_2}{\frac{(y_1 - mx_1) - (y_2 - mx_2)}{\ln \frac{y_1 - mx_1}{y_2 - mx_2}}} = 2.848; H = H_{OG} \times N_{OG} = 2.53 \text{ m}$

(3) 只改变 x_2 的值不影响 N_{OG} 的值和 $\frac{1}{A}$ 的值, $x_2' = 0.0015$

根据 $N_{OG} = \frac{1}{1 - \frac{1}{A}} \ln \left[\left(1 - \frac{1}{A} \right) \frac{y_1 - mx_2}{y_2 - mx_2} + \frac{1}{A} \right]$

\therefore 有 $\frac{y_1 - mx_2}{y_2 - mx_2} = \frac{y_1 - mx_2'}{y_2' - mx_2'}$, 解得 $y_2' = 2.794 \times 10^{-3}, \eta' = \frac{y_1 - y_2'}{y_2'} = 94.4\% < 98\%$, 故不满足

6. $w_1 = 5\%, w_2 = 1\%, P = 101.33 \text{ kPa}$

$$G_1 = 0.8 \text{ kg/s}, t_0 = 20^\circ\text{C}, H_0 = 0.005 \text{ kg 水/kg 绝干气}, t_1 = 150^\circ\text{C}$$

$$(1) t_2 = 70^\circ\text{C}, X_1 = \frac{w_1}{1-w_1} = 0.0526, X_2 = \frac{w_2}{1-w_2} = 0.0101$$

$$G_c = G_1(1-w_1) = 0.8 \times (1-0.05) = 0.76 \text{ kg 绝干物料/s}$$

$$W = G_c(X_1 - X_2) = 0.76 \times (0.0526 - 0.0101) = 0.0323$$

$$\text{理想干燥 } I_1 = I_2 \Rightarrow (1.01 + 1.88H_1)t_1 + 2500H_1 = (1.01 + 1.88H_2)t_2 + 2500H_2$$

$$H_0 = H_1, \text{ 解得 } H_2 = 0.0353 \text{ kg 水/kg 绝干气}$$

$$L = \frac{W}{H_2 - H_1} = \frac{0.0323}{0.0353 - 0.005} = 1.066 \text{ kg 绝干气/h}$$

$$Q_p = L(I_1 - I_0) = 1.066 \times (1.01 + 1.88 \times 0.005) \times (150 - 20) = 141.27 \text{ kJ/h}$$

(2) 当 $t_2 = 70^\circ\text{C}$ 时, 干燥器出口空气中水汽分压为

$$P_2 = \frac{PH_2}{0.622 + H_2} = \frac{101.33 \times 0.0353}{0.622 + 0.0353} = 5.442 \text{ kPa}$$

$t = 60^\circ\text{C}$ 时, 饱和蒸汽压 $P_s = 19.919 \text{ kPa}$, P_s 大于 P_2

故不会发生返潮