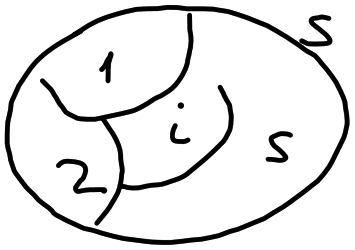
$$y = \frac{n_i}{n} \rightarrow \sum_1^s y_i = 1$$

$$fm = \frac{m_i}{m} \rightarrow \sum_1^s fm = 1$$



AIRE SECO — $(kg/kmol)$ — m, m_i, n, n_i

	$y_{i\,real}$	y_i	fm_i	M_i
N_2	0.78	79%	76%	28
O_2	0.21	21%	24%	32
CO_2, CO, CH_4, Ar	0.01			

$$m = \sum_1^s m_i \qquad n = \sum_1^s n_i$$

$$y_i = \frac{n_i}{n}$$

$$n = \frac{m}{M} \rightarrow m = n M \quad m_i = n_i M_i$$

$$fm_i = \frac{m_i}{m} \Rightarrow fm_i = \frac{n_i M_i}{n M} \Rightarrow fm_i = y_i \frac{M_i}{M}$$

($\frac{n_i}{n} = y_i$)

$$n = \frac{m}{M} \Rightarrow M = \frac{m}{n} \left\{ \begin{array}{l} m = \sum_1^s m_i \\ m_i = n_i M_i \end{array} \right\} \Rightarrow M = \frac{\sum_1^s m_i}{n} = \sum_1^s \frac{m_i}{n} \Rightarrow$$

$$\Rightarrow M = \sum_1^s \frac{n_i M_i}{n} \Rightarrow M = \sum_1^s y_i M_i$$

($\frac{n_i}{n} = y_i$)

$$M = 0.21 \times 32 \frac{kg}{kmol} + 0.79 \times 28 \frac{kg}{kmol} = 28.97 \frac{kg}{kmol}$$

$$fm_{N_2} = 0.79 \times \frac{28\ kg/kmol}{28.97\ kg/kmol} = 0.764$$

$$fm_{O_2} = 0.21 \times \frac{32\ kg/kmol}{28.97\ kg/kmol} = 0.232$$

$P = 1\ bar$

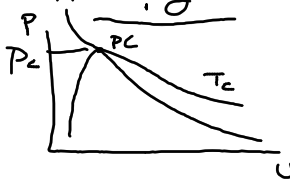
$T = 295\ K$

$T_c = 133\ K$

$P_c = 37.7\ bar$

$\rightarrow \begin{cases} P_R = 0.027 \\ T_R = 2.218 \end{cases}$

$M = \sum_i^s y_i M_i$



$P_c = \sum_i^s y_i P_{c,i}$

$T_c = \sum_i^s y_i T_{c,i}$

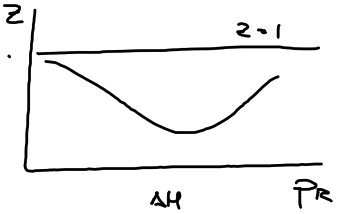
→ LEY o REGLA DE KAY

AIRE HUMEDO = a + v

DALTON (Gi G.7.)

$P = \sum_i^s P_i$

$P = P_a + P_v$



$\omega = \frac{m_v}{m_a}$

$\phi = HR = \frac{m_v}{m_{sat}}$

$P_a V = m_a R_a T$

$P_v V = m_v R_v T$

$P_v = \frac{m_v R_v T}{V}$

$\omega = \frac{m_v}{m_a}$

$m_v = \frac{P_v V}{R_v T}$

$m_a = \frac{P_a V}{R_a T}$

$\Rightarrow \omega = \frac{\frac{P_v V}{R_v T}}{\frac{P_a V}{R_a T}} = \frac{R_a}{R_v}\frac{P_v}{P_a} \Rightarrow$

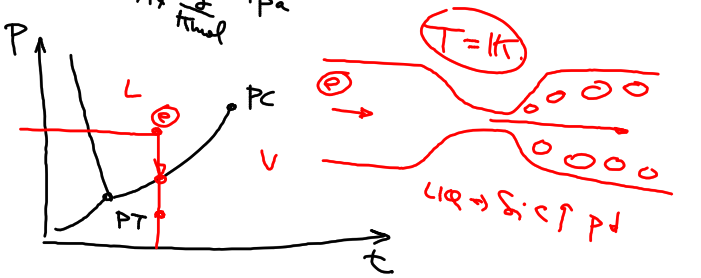
$R_a = \frac{R}{M_a}, R_v = \frac{R}{M_v}$

18 kg/kmol

$\Rightarrow \omega = \frac{M_v}{M_a}\frac{P_v}{P - P_v} \Rightarrow \omega = 0.622 \frac{P_v}{P - P_v} = \frac{m_v}{m_a}$

28.97 kg/kmol

P_a



$t = 23°C$

$P_v = 0.01228$ bar → $P_{sat}(10°C)$

$P = 1$ bar

$P_a = 1$ bar − 0.01228 bar = ...

$\phi = 60\%$

$V = 300\ m^3$

$P_{atm} = 0.9$ bar = 90 kPa = 900 mbar = 900 hPa

$t = 22°C$

$\phi = 60\%$

$V = 300\ m^3$

$P_{atm} = 0.9\ bar = 90\ kPa = 900\ mbar = 900\ hPa$

$t = 22^\circ C$

¿ $m_v\ (kg)$?

$$\omega = 0.622 \frac{P_v}{P - P_v} = \frac{m_v}{m_a}$$

$$\phi = \frac{m_v}{m_{sat}}$$

$$m_v = \frac{P_v V}{R_v T}$$

$$m_{sat} = \frac{P_{sat}(T)\, V}{R_v T}$$

$$\Rightarrow \phi = \frac{\frac{P_v V}{R_v T}}{\frac{P_{sat}(T) V}{R_v T}} = \frac{P_v}{P_{sat}(T)}$$

$$\phi = 60\% \Rightarrow 0.60 = \frac{P_v}{P_{sat}(T)} \Rightarrow$$

$$\Rightarrow P_v = 0.60 \cdot 0.02645\ bar = 0.01587\ bar$$

$$m_a = \frac{P_a V}{R_a T} \Rightarrow m_a = \frac{(P - P_v) \times 100 \frac{kPa}{bar}\ 300\ m^3}{0.287 \frac{kJ}{kg\,K} \times 295.15\ K}$$

$$m_a = 313.12\ kg_a$$

$$\omega = 0.622 \frac{0.01587\ bar}{0.9\ bar - 0.01587\ bar} = \frac{m_v}{313.12\ kg_a}$$

$$m_v = 3.49\ kg_v$$

¿ CUÁNTOS kg_v MÁXIMO?

$$\omega = 0.622 \frac{0.02645\ bar}{0.9\ bar - 0.02645\ bar} = \frac{m_{sat}}{309.37\ kg_a}$$

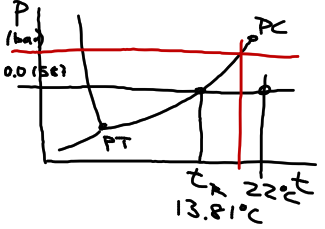
$$\phi = 100\% \Rightarrow 1 = \frac{P_v}{P_{sat}(t)} \Rightarrow P_v = P_{sat}(t)$$

$$m_a = \frac{P_a V}{R_a T} \Rightarrow m_a = \frac{(0.9\ bar - 0.02645\ bar) \times 100 \frac{kPa}{bar} \times 300\ m^3}{0.287 \frac{kJ}{kg\,K} \times 295\ K}$$

$$m_a = 309.37\ kg$$

$$m_{sat} = 5.82\ kg$$

TROCÍO — DEW POINT.

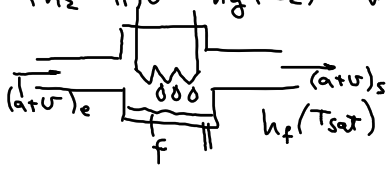


$$U = U_a + U_v$$

$$H = H_a + H_v$$

$$S = S_a + S_v$$

$$H = H_a + H_v$$
$$H_a = m_a h_a = n_a \bar{h}_a$$
$$H_v = m_v h_v = n_v \bar{h}_v$$
$$\Rightarrow H = m_a h_a + m_v h_v \Rightarrow$$
$$\Rightarrow \frac{H}{m_a} = h = h_a + \frac{m_v}{m_a} h_v \Rightarrow \underline{h = h_a + \omega h_v}$$
$$U = m_a u_a + m_v u_v$$
$$S = m_a s_a + m_v s_v$$
$$H_2 - H_1 = m_a (h_2 - h_1)_a + m_v (h_2 - h_1)_v$$
$$h_2 - h_1 \underset{G.I.}{=} h(T_2) - h(T_1) \underset{TABLAS}{=} c_p (T_2 - T_1) \underset{G.P.}{=}$$
$c_p \downarrow 1.005 \frac{kJ}{kg\,K}$
$$h_v(t, p_v) \simeq h_g(t)$$
$$(h_2 - h_1)_v = h_g(t_2) - h_g(t_1)$$



12.35

0.5 m³
35°C
1 bar
70% HR
29°C
p = ctte
p = ctte

$$\Delta U = Q - W$$
$$W = \int_i^f p\,dV \Rightarrow W = p(V_f - V_i)$$
$$V_f = \frac{m R T}{p_f}$$

$$Q = \Delta U + W$$
$$\Delta U = U_f - U_i = \underbrace{m_{af} u_{af}}_{U_{af}} + \underbrace{m_{vf} u_{vf}}_{U_{vf}} - \ldots$$
$$\ldots - (\underbrace{m_{ai} u_{ai}}_{U_{ai}} + \underbrace{m_{vi} u_{vi}}_{U_{ai}}) = \ldots$$
$$\ldots = \Delta U = m_a (u_{af} - u_{ai}) + m_v (u_{vf} - u_{vi}) \underset{G.P.}{=} \ldots$$
$$\ldots = \Delta U = m_a c_{pa} (T_f - T_i) + m_v \left[u_g(T_f) - u_g(T_i) \right]$$
$$\omega = 0.622 \frac{p_v}{p - p_v} = \frac{m_v}{m_a}$$
$$\phi = \frac{p_v}{p_{sat}(t)} \Rightarrow p_v = \phi\, p_{sat}(t) \Rightarrow$$
$$\Rightarrow p_v = 0.70 \times p_{sat}(35°C) \Rightarrow$$
$$\Rightarrow p_v = 0.70 \times 0.056286\ bar = \ldots$$
$$\ldots = 0.039396\ bar$$

$$\omega = 0.622 \times \frac{0.03934\ bar}{1 - 0.03934\ bar} = \dots$$

$$\dots = \omega = 0.0255 \frac{kg_v}{kg_a} = \frac{m_v}{m_a}$$

$$p_a V = m_a R_a T \Rightarrow$$

$$\Rightarrow m_a = \frac{p_a V}{R_a T} = \frac{(p - p_v) \cdot V}{R_a T} \Rightarrow$$

$$\Rightarrow m_a = \frac{(1 - 0.03934) \times 100\ kPa \times 0.5\ m^3}{0.287 \frac{kJ}{kg\,K} \times 308.15\ K} = \dots$$

$$\dots = m_a = 0.54\ kg_a$$

$$\omega = \frac{m_v}{m_a} \Rightarrow m_v = \omega\, m_a \Rightarrow m_v = 0.0255 \frac{kg_v}{kg_a} \times 0.54\ kg_a$$

$$\Rightarrow m_v = 0.014\ kg_v$$

$$\Delta U = 0.54\ kg_a \times 1.005 \frac{kJ}{kg_a K} \times (29 - 35)\ K + \dots$$

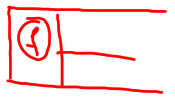
$$\dots + 0.014\ kg_v \left[u_g(T_f) - u_g(T_i) \right] \frac{kJ}{kg_v} = \dots$$

($u_g(T_f) = 2414.59$, $u_g(T_i) = 2422.69$)

$$\dots = \Delta U = -3.3895\ kJ$$

$$W = p(V_f - V_i)$$

$V_f \Rightarrow \frac{V_i}{V_f} = \frac{T_i}{T_f}$ $\left(\frac{pV}{T} = k\right)$



$pV = mRT$.

$pV = n\bar{R}T$

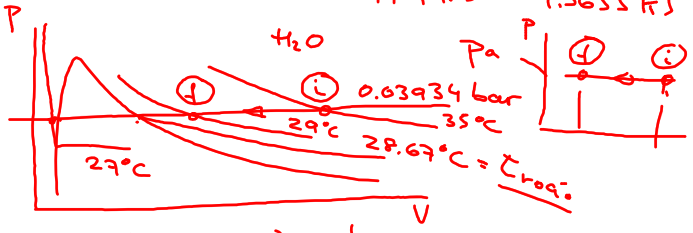
$$\frac{R_i V_i}{T_i} = \frac{R_f V_f}{T_f} \Rightarrow \frac{V_i}{V_f} = \frac{T_i}{T_f} \Rightarrow V_f = V_i \frac{T_f}{T_i}$$

$$W = p V_i \left[\frac{T_f}{T_i} - 1 \right] \Rightarrow$$

$$\Rightarrow W = 100\ kPa \times 0.5\ m^3 \left[\frac{302\ K}{308\ K} - 1 \right] = \dots$$

$$\dots = W = -0.974\ kJ$$

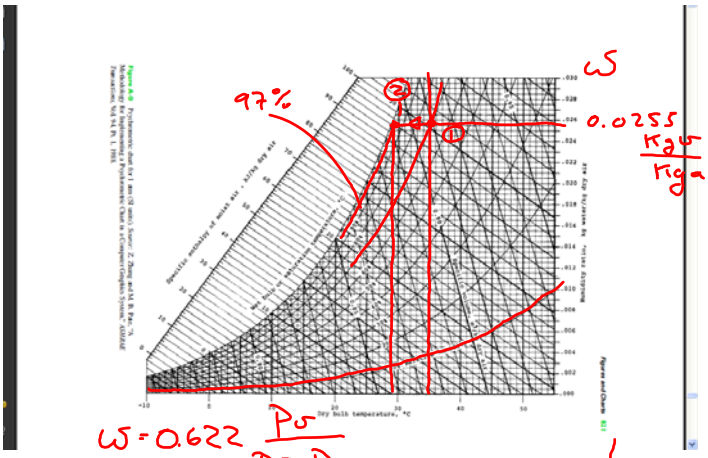
$$Q = -3.3895\ kJ - 0.974\ kJ) = -4.3635\ kJ$$



$W = k\ (i \to f)$ ¿ϕ?

$$\phi = \frac{p_v}{p_{sat}(t)} \Rightarrow \phi = \frac{0.03934\ bar}{0.0400..\ bar} = 0.984$$

98.4 %.

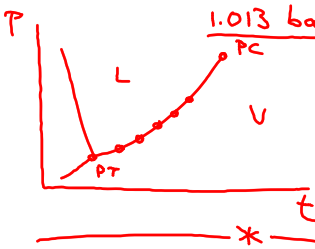


$$\omega = 0.622 \frac{P_v}{P - P_v}$$

$$\phi = \frac{P_v}{P_{sat}(t)} \Rightarrow P_v = \phi P_{sat}(t)$$

$$\omega = 0.622 \frac{\phi P_{sat}(t)}{P - \phi P_{sat}(t)}$$

$$\omega = 0.622 \frac{0.10\, P_{sat}(t)}{1.013\ bar - 0.10\, P_{sat}(t)}$$



$$\dot{Q} = \dot{m}(h_s - h_e)$$

e: 10°C, 80%, 150 $\frac{m^3}{min}$ ② ¿$\dot{Q}$ ($\frac{kJ}{min}$)? ⑤ ¿ϕ_s (%)?

P = 1K (1 bar)

s: 30°C

$$\phi_s = \frac{P_{vs}}{P_{sat}(t_s)}$$

$$P_{sat}(30°C) = 0.04246\ bar$$

$$\omega_e = 0.622 \frac{P_{ve}}{P - P_{ve}} \Rightarrow$$

$$\Rightarrow \omega_e = 0.622 \frac{\phi_e P_{sat}(t_e)}{P - \phi_e P_{sat}(t_e)} \Rightarrow$$

$$\Rightarrow \omega_e = 0.622 \frac{0.80 \times 0.01228\ bar}{1\ bar - 0.80 \times 0.01228\ bar}$$

$$\Rightarrow \omega_e = 6.17 \times 10^{-3} \frac{kg_v}{kg_a} = \omega_s$$

$$6.17 \times 10^{-3} \frac{kg_v}{kg_a} = 0.622 \times \frac{\phi_s P_{sat}(t_s)}{P - \phi_s P_{sat}(t_s)}$$

$P \downarrow 1\ bar,\ P_{sat}(30°C) = 0.04246\ bar$

$$\phi_s = 23.1\ \%$$

$$\frac{dE}{dt} = \dot{Q} - \dot{W} + \dot{m}_e\left(h_e + \frac{1}{2}c_e^2 + gz_e\right) - \ldots$$
$$\ldots - \dot{m}_s\left(h_s + \frac{1}{2}c_s^2 + gz_s\right)$$

$$\dot{Q} = \dot{m}_s h_s - \dot{m}_e h_e \Rightarrow \dot{Q} = \sum \dot{m}_s h_s - \sum \dot{m}_e h_e$$

$$\sum \dot{m}_e h_e = \dot{m}_{ae} h_a(t_e) + \dot{m}_{ve} h_g(t_e)$$

$$\sum \dot{m}_s h_s = \dot{m}_{as} h_a(t_s) + \dot{m}_{vs} h_g(t_s)$$

$$\frac{dm}{dt}^{0(\text{est.})} = \dot{m}_e - \dot{m}_s \Rightarrow \dot{m}_e = \dot{m}_s \Rightarrow \begin{cases} \dot{m}_{ae} = \dot{m}_{as} \\ \dot{m}_{ve} = \dot{m}_{vs} \end{cases}$$

$$\dot{Q} = \dot{m}_a\left[h_a(t_s) - h_a(t_e)\right] + \dot{m}_v\left[h_g(t_s) - h_g(t_e)\right]$$

$$\dot{Q} = \dot{m}_a c_p (T_s - T_e) + \dot{m}_v\left[h_g(t_s) - h_g(t_e)\right]$$

$$AC = 150\ \frac{m^3}{min} = \frac{150}{60}\ \frac{m^3}{s} = 2.5\ \frac{m^3}{s}$$

$$\dot{m}_a = \frac{AC}{v_a} \left\{ \Rightarrow \dot{m}_a = \rho_a \frac{AC}{R_a T} \right. \quad \left. \Rightarrow \right.$$
$$v_a = \frac{R_a T}{p_a} \qquad p = p_a + p_v \Rightarrow p_a = p - p_v$$

$$\Rightarrow \dot{m}_a = (p - p_v)\frac{AC}{R_a T} \left. \right\} \Rightarrow$$
$$\phi = \frac{p_v}{p_{sat}(t)} \Rightarrow p_v = \phi\, p_{sat}(t) \left. \right\}$$

$$\Rightarrow \dot{m}_a = \left[p - \phi p_{sat}(t)\right]\frac{AC}{R_a T} \Rightarrow$$

$$\Rightarrow \dot{m}_a = \left[100\ kPa - 0.80 \times 1.228\ kPa\right] \times \ldots$$
$$\ldots \times \frac{2.5\ \frac{m^3}{s}}{0.287\ \frac{kJ}{kg\,K} \times 283.15\ K} = 3.05\ \frac{kg_a}{s}$$

$$\omega_e = \frac{m_{ve}}{m_{ae}} = \frac{\dot{m}_v}{\dot{m}_a}\ \frac{kg_v}{kg_a} \Rightarrow \dot{m}_v = \omega \dot{m}_a \Rightarrow$$

$$\Rightarrow \dot{m}_v = 6.17 \times 10^{-3}\ \frac{kg_v}{kg_a} \times 3.05\ \frac{kg_a}{s} = 0.018\ \frac{kg_v}{s}$$

$$\dot{Q} = 3.05\ \frac{kg_a}{s} \times 1.005\ \frac{kJ}{kg_a K} \times (30 - 10)\ K + \ldots$$
$$\ldots + 0.018\ \frac{kg_v}{s} \times \left[2556.3 - 2519.8\right]\ \frac{kJ}{kg_v} = \ldots$$
$$\ldots = 61.96\ kW$$

¿Si SÓLO a ?

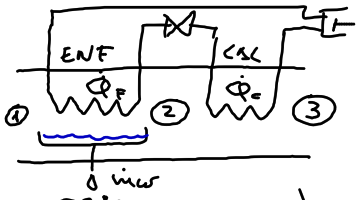
$$\dot{Q} = \dot{m}_a (h_s - h_e) = \dot{m}_a c_p (T_s - T_e)$$

$$\dot{m}_a = \frac{AC}{v_a} = \frac{AC}{\frac{R_a T}{p}} \Rightarrow \dot{m}_a = 100\ kPa\ \frac{2.5\ \frac{m^3}{s}}{0.287\ \frac{kJ}{kg\,K} \times 283\ K}$$
$$\dot{m}_a = 3.08\ \frac{kg}{s}$$

$$\dot{Q} = 3.08\ \frac{kg}{s} \times 1.005\ \frac{kJ}{kg\,K} \times (30 - 10)\ K = 61.91\ kW$$

$$\varepsilon_r = \pm \frac{|61.91 - 61.96|}{61.96} \times 100 = 0.08\ \%.$$

——— 12.45 ———



① $28\,^\circ C$, 1 bar, $\phi = 70\%$, $50\ \frac{m^3}{min}$ ② 1 bar, $\phi = 100\%$ ③ $24\,^\circ C$, $40\% = \phi$, 1 bar

(a) ¿t_2 (°C)?

(b) ¿$\dot{m}_w$ ($\frac{kg}{min}$)?

(c) ¿$\dot{Q}_F$ (kW)?

(d) ¿$\dot{Q}_C$ (kW)?

$$\phi_2 = \frac{p_{v2}}{p_{sat}(t_2)} \left.\begin{array}{l} \\ \phi_2 = 1 \end{array}\right\} \Rightarrow p_{v2} = p_{sat}(t_2)$$

$$\omega_3 = 0.622\,\frac{p_{v3}}{p - p_{v3}} = 0.622\,\frac{\phi_3 p_{sat}(t_3)}{p - \phi_3 p_{sat}(t_3)}$$

$$\Rightarrow \omega_3 = 0.622\,\frac{0.40 \times 2.986\times10^{-2}\ bar}{(1 - 0.40 \times 2.986\times10^{-2})\ bar} = \ldots$$

$$\ldots = \omega_3 = \omega_2 = 7.52\times10^{-3}\,\frac{kg_v}{kg_a}$$

$$\omega_2 = 0.622\,\frac{p_{v2}}{p - p_{v2}} \Rightarrow p - p_{v2} = \frac{0.622}{\omega_2}\,p_{v2} \Rightarrow$$

$$\Rightarrow p_{v2}\left(\frac{0.622}{\omega_2} + 1\right) = p \Rightarrow p_{v2} = \frac{p}{\frac{0.622}{\omega_2} + 1} \Rightarrow$$

$$\Rightarrow p_{v2} = \frac{1\ bar}{\frac{0.622}{7.52\times10^{-3}} + 1} = 0.012\ bar \approx 9.7\,^\circ C$$

$\dot{m}_w$

$$\dot{m}_{a1} = \dot{m}_{a2}$$

$$\dot{m}_{v1} = \dot{m}_w + \dot{m}_{v2} \Rightarrow \dot{m}_w = \dot{m}_{v1} - \dot{m}_{v2} \left.\begin{array}{l} \\ \omega = \frac{\dot{m}_v}{\dot{m}_a} \end{array}\right\} \Rightarrow$$

$$\Rightarrow \dot{m}_w = \dot{m}_a(\omega_1 - \omega_2)$$

$$\omega_1 = 0.622\,\frac{p_{v1}}{p - p_{v1}} = 0.622\,\frac{\phi_1 p_{sat}(t_1)}{p - \phi_1 p_{sat}(t_1)}$$

$$\omega_1 = 0.622\,\frac{0.70 \times 0.037836\ bar}{1\ bar - 0.70 \times 0.037836\ bar} = 0.0169\,\frac{kg_v}{kg_a}$$

$$\dot{m}_a = \frac{\Delta C}{\frac{R_a T}{p - p_{v1}}} \Rightarrow \dot{m}_a = (1 - 0.70 \times 0.037836)\ bar \times 100\,\frac{kPa}{bar} \ldots \times \frac{\frac{50}{60}\,\frac{m^3}{s}}{0.287\,\frac{kJ}{kg_a K} \times (28 + 273.15) K} = \ldots$$

$$\ldots = \dot{m}_a = 0.939\,\frac{kg_a}{s}$$

$$\dot{m}_w = 0.939\,\frac{kg_a}{s} \times (0.0169 - 7.52\times10^{-3})\,\frac{kg_v}{kg_a} = \ldots$$

$$\ldots = \dot{m}_w = 8.81\times10^{-3}\,\frac{kg}{s} = 31.7\,\frac{kg}{h}$$

$$\dot{Q}_F = \Sigma(\dot{m}h)_s - \Sigma(\dot{m}h)_e \quad (1 \to 2)$$

$$\Sigma(\dot{m}h)_e = \dot{m}_a h_a(t_e) + \dot{m}_{v1} h_g(t_e)$$

$$\Sigma(\dot{m}h)_s = \dot{m}_a h_a(t_s) + \dot{m}_{v2} h_g(t_2) + \dot{m}_w h_f(t_2)$$

$$\dot{Q}_F = \dot{m}_a c_p (t_s - t_e) + \dot{m}_{v2} h_g(t_2) - \dot{m}_{v1} h_g(t_1) + \ldots$$
$$\ldots + \dot{m}_w h_f(t_2)$$

$$\dot{Q}_F = 0.939 \frac{kg_a}{s} \times 1.005 \frac{kJ}{kg\,K} \times (9.7 - 28)\,K + \ldots$$
$$\ldots + 7.52 \times 10^{-3} \frac{kg_v}{kg_a} \times 0.939 \frac{kg_a}{s} \times 2518.68 \frac{kJ}{kg} + \ldots$$
$$\ldots - 0.0169 \frac{kg_v}{kg_a} \times 0.939 \frac{kg_a}{s} \times 2551.97 \frac{kJ}{kg} + \ldots$$
$$\ldots + 8.81 \times 10^{-3} \frac{kg_w}{s} \times 40.762 \frac{kJ}{kg_w} = -39.7\,kW$$

$$\dot{Q}_c = \Sigma(\dot{m}h)_s - \Sigma(\dot{m}h)_e$$

$$\Sigma(\dot{m}h)_s = \dot{m}_a h_a(t_s) + \dot{m}_v h_g(t_s)$$

$$\Sigma(\dot{m}h)_e = \dot{m}_a h_a(t_e) + \dot{m}_v h_g(t_e)$$

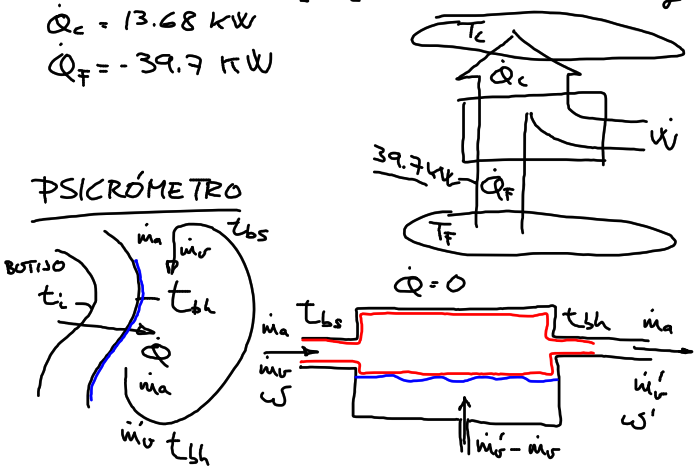
$$\Rightarrow \dot{Q}_c = \dot{m}_a [h_a(t_s) - h_a(t_e)] + \dot{m}_v [h_g(t_s) - h_g(t_e)]$$

$$\Rightarrow \dot{Q}_c = \dot{m}_a c_p (t_s - t_e) + \dot{m}_v [h_g(t_s) - h_g(t_e)]$$

$$\Rightarrow \dot{Q}_c = 0.939 \frac{kg}{s} \times 1.005 \frac{kJ}{kg\,K} \times (24 - 9.7)\,K + \ldots$$
$$\ldots + 7.06 \times 10^{-3} \frac{kg}{s} \times [2544.73 - 2518.68] \frac{kJ}{kg}$$

$$\dot{Q}_c = 13.68\,kW$$

$$\dot{Q}_F = -39.7\,kW$$



$$0 = \dot{Q} - \dot{W} + \Sigma \dot{m}_e h_e - \Sigma \dot{m}_s h_s$$

$$\Sigma \dot{m}_e h_e = \dot{m}_a h_a(t_{bs}) + \dot{m}_v h_g(t_{bs}) + (\dot{m}_v' - \dot{m}_v) h_f(t_{bh})$$

$$\Sigma \dot{m}_s h_s = \dot{m}_a h_a(t_{bh}) + \dot{m}_v' h_g(t_{bh})$$

$$0 = \dot{m}_a [h_a(t_{bs}) - h_a(t_{bh})] + \dot{m}_v h_g(t_{bs}) + \ldots$$
$$\ldots + (\dot{m}_v' - \dot{m}_v) h_f(t_{bh}) - \dot{m}_v' h_g(t_{bh}) \to (\div \dot{m}_a)$$

$$\Rightarrow 0 = [h_a(t_{bs}) - h_a(t_{bh})] + W h_g(t_{bs}) + \ldots$$
$$\ldots + (W' - W) h_f(t_{bh}) - W' h_g(t_{bh}) \Rightarrow$$

$$\Rightarrow h_a(t_{bh}) - h_a(t_{bs}) = W [h_g(t_{bs}) - h_f(t_{bh})] + \ldots$$
$$\ldots + W' [h_f(t_{bh}) - h_g(t_{bh})] \Rightarrow$$

$$\Rightarrow h_a(t_{bh}) - h_a(t_{bs}) = w\left[h_g(t_{bs}) - h_f(t_{bh})\right] + \ldots$$
$$\ldots + w'\left[h_f(t_{bh}) - h_g(t_{bh})\right] \Rightarrow$$

$$\Rightarrow w = \frac{h_a(t_{bh}) - h_a(t_{bs}) - w'\left[h_f(t_{bh}) - h_g(t_{bh})\right]}{h_g(t_{bs}) - h_f(t_{bh})}$$

$w' \rightarrow \phi' = 1 \Rightarrow w' = 0.622 \dfrac{p_{sat}(t_{bh})}{p - p_{sat}(t_{bh})}$ (donde $p'_v = p_{sat}(t_{bh})$)

$$w = 0.622 \frac{p_v(t_{bs})}{p - p_v(t_{bs})} \Rightarrow \left[p - p_v(t_{bs})\right]\frac{w}{0.622} = \ldots$$

$$\ldots = p_v(t_{bs}) \Rightarrow p\frac{w}{0.622} = p_v(t_{bs})\left[\frac{w}{0.622} + 1\right] \Rightarrow$$

$$\Rightarrow p_v(t_{bs}) = \frac{p\frac{w}{0.622}}{\frac{w}{0.622} + 1}$$

$$\phi = \frac{p_v(t_{bs})}{p_{sat}(t_{bs})}$$

$t_{bs} = 22\,^\circ C$, $t_{bh} = 16\,^\circ C$, $p_{atm} = 90\,kPa$

$c\phi$?

$$w = \frac{h_a(t_{bh}) - h_a(t_{bs}) - w'\left[h_f(t_{bh}) - h_g(t_{bh})\right]}{h_g(t_{bs}) - h_f(t_{bh})}$$

$$w = \frac{1.005\,\frac{kJ}{kg\,a}\times(16-22)\,a - 0.0128\,\frac{kg_v}{kg_a}\left[67.19 - 2530.8\right]\frac{kJ}{kg_v}}{(2541.7 - 67.19)\,\frac{kJ}{kg_v}}$$

$$w' = 0.622 \frac{p_{sat}(16^\circ C)}{p - p_{sat}(16^\circ C)} \Rightarrow$$

$$w' = 0.622 \frac{0.01818\ bar}{0.90\ bar - 0.01818\ bar} = 0.0128\,\frac{kg_v}{kg_a}$$

$$\ldots = w = 0.01031\ kg_v/kg_a$$

$$w = 0.622 \frac{p_v(t_{bs})}{p - p_v(t_{bs})} \Rightarrow$$

$$\Rightarrow wp - wp_v(t_{bs}) = 0.622\,p_v(t_{bs}) \Rightarrow wp = p_v(t_{bs})(0.622 + w) \Rightarrow$$

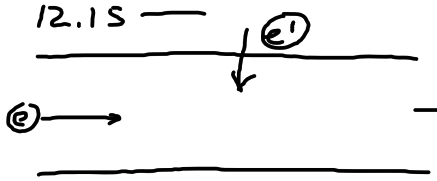
$$\Rightarrow p_v(t_{bs}) = p\frac{w}{0.622 + w} \Rightarrow$$

$$\Rightarrow p_v(t_{bs}) = 0.90\ bar\ \frac{0.01031}{0.622 + 0.01031} = 0.01467\ bar$$

$$\phi = \frac{p_v(t_{bs})}{p_{sat}(t_{bs})} \Rightarrow \phi = \frac{0.01467\ bar}{0.02645\ bar} = 0.5548 \Rightarrow$$

$$\Rightarrow \phi = 55.48\,\%$$

12.15



¿ω?
¿t?

e { 22°C
$t_{bh} = 9°C$

$\dot{m}_{ve} + \dot{m}_{ve'} = \dot{m}_{vs}$

$p = 1$ atm

$\dot{m}_a = 90 \frac{kg}{min}$

e' { $x = 1$
110°C
52 kg/h

$\dot{m}_e = \dot{m}_s$

$0 = 0 - 0 + \sum \dot{m}_e h_e - \sum \dot{m}_s h_s$

$\sum \dot{m}_e h_e = \dot{m}_a h_a(t_{bs}) + \dot{m}_{ve} h_g(t_{bs}) + \dots$

$\dots + \dot{m}_{ve'} h_g(t_{e'})$

$\sum \dot{m}_s h_s = \dot{m}_a h_a(t_s) + \dot{m}_{vs} h_g(t_s)$

$\dot{m}_a [h_a(t_{bs}) - h_a(t_s)] + \dot{m}_{ve} h_g(t_{bs}) + \dot{m}_{ve'} h_g(t_{e'}) \dots$

$\dots - \dot{m}_{vs} h_g(t_s) = 0$

$t_{bse} = 22°C$
$t_{she} = 9°C$ $\Rightarrow \omega_e = 0.0019 \frac{kg_v}{kg_a} = \frac{\dot{m}_{ve}}{\dot{m}_a} \Rightarrow$

$\Rightarrow \dot{m}_{ve} = 0.0019 \frac{kg_v}{kg_a} \cdot \frac{90}{60} \frac{kg}{s} = 0.0028 \frac{kg_v}{s}$

$\dot{m}_{vs} = \dot{m}_{ve} + \dot{m}_{ve'} \Rightarrow$

$\Rightarrow \dot{m}_{vs} = 0.0028 \frac{kg}{s} + \frac{52}{3600} \frac{kg}{s} = 0.01724 \frac{kg}{s}$

$\frac{90}{60} \frac{kg}{s} \cdot 1.005 \frac{kJ}{kg\,K} (22 - t_s) K + 0.0028 \frac{kg}{s} \cdot 2541.7 \frac{kJ}{kg} + \dots$

$\dots + \frac{52}{3600} \frac{kg}{s} \cdot 2691.5 \frac{kJ}{kg} - 0.01724 \frac{kg}{s} \cdot h_g(t_s) = 0$

Si $t_s = 50°C \rightarrow h_g(50°C) = 2592.1 \frac{kJ}{kg}$

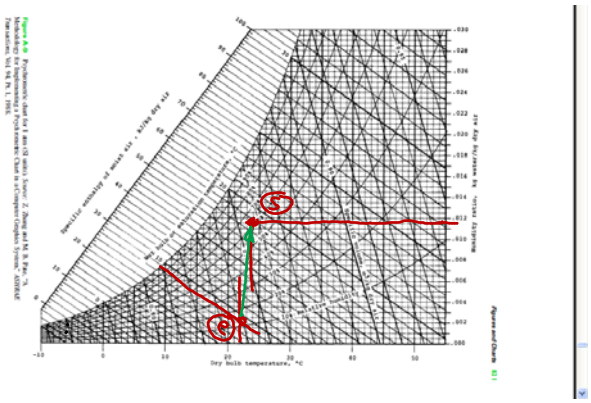
$EQ(t_s = 50°C) = -40.90 \neq 0$

$EQ(t_s = 30°C) = -10 \neq 0$

$EQ(t_s = 25°C) = -2.44 \neq 0$

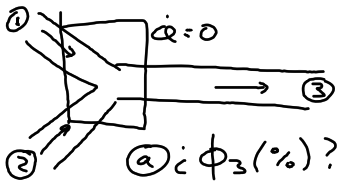
$t_s = 24°C$

$\omega = \frac{\dot{m}_{vs}}{\dot{m}_a} = 0.0115 \frac{kg_v}{kg_a}$



Enfriamiento evaporativo

12.55



① $\begin{cases} 36^\circ C \\ 1\ bar \\ 40\% = \phi \\ \dot{m}_1 = 2.5\ \frac{kg}{min} \end{cases}$

② $\begin{cases} \phi = 100\% \\ 5^\circ C \\ 1\ bar. \\ \dot{m}_2 = 5\ \frac{kg}{min} \end{cases}$

ⓐ ¿$\phi_3(\%)$?
¿$t_3(^\circ C)$?

$\dot{m}_{a1} + \dot{m}_{a2} = \dot{m}_{a3}$

$\dot{m}_{v1} + \dot{m}_{v2} = \dot{m}_{v3}$

$\Sigma(\dot{m}h)_e = \Sigma(\dot{m}h)_s$

$\dot{m}_{a1}h_a(t_1) + \dot{m}_{v1}h_g(t_1) + \dot{m}_{a2}h_a(t_2) + \dot{m}_{v2}h_g(t_2) = \dots = \dot{m}_{a3}h_a(t_3) + \dot{m}_{v3}h_g(t_3)$

$\phi_3 = \dfrac{P_{v3}}{P_{sat}(t_3)}$

$\omega_3 = 0.622\ \dfrac{P_{v3}}{P - P_{v3}} = \dfrac{\dot{m}_{v3}}{\dot{m}_{a1} + \dot{m}_{a2}}$

$\phi_1 = \dfrac{P_{v1}}{P_{sat}(t_1)} \Rightarrow P_{v1} = \phi_1 P_{sat}(t_1) \Rightarrow$

$\Rightarrow \omega_1 = 0.622\ \dfrac{\phi_1 P_{sat}(t_1)}{P - \phi_1 P_{sat}(t_1)} \Rightarrow$

$\Rightarrow \omega_1 = 0.622\ \dfrac{0.4 \times 0.05947\ bar}{1\ bar - 0.4 \times 0.05947\ bar} = 0.0152\ \frac{kg_v}{kg_a}$

$\begin{cases} \dfrac{\dot{m}_{v1}}{\dot{m}_{a1}} = 0.0152\ \frac{kg_v}{kg_a} \\ \dot{m}_{a1} + \dot{m}_{v1} = \dfrac{2.5}{60}\ \frac{kg}{s} \Rightarrow \dot{m}_{a1} + 0.0152\ \frac{kg_v}{kg_a}\dot{m}_{a1} = \dots \end{cases}$

$\dots = \dfrac{2.5}{60}\ \frac{kg}{s}$

$\Rightarrow \dot{m}_{a1} = 0.041\ \frac{kg}{s}$

$\omega_2 = 0.622\ \dfrac{P_{sat}(t_2)}{P - P_{sat}(t_2)} \Rightarrow \omega_2 = 0.622\ \dfrac{0.00872\ bar}{1\ bar - 0.00872\ bar}$

$\Rightarrow \omega_2 = 0.0055\ \frac{kg_v}{kg_a} = \dfrac{\dot{m}_{v2}}{\dot{m}_{a2}}$

$\dot{m}_{a2} + \dot{m}_{v2} = \dfrac{5}{60}\ \frac{kg}{min}$

$\omega_2 = 0.0055 \frac{kg_v}{kg_a} = \frac{\dot{m}_{v2}}{\dot{m}_{a2}}$

$\dot{m}_{a2} + \dot{m}_{v2} = \frac{5}{60} \frac{kg}{min}$

$\dot{m}_{a2} = 0.0829 \ kg_a/s$

$\dot{m}_{v2} = 0.0055 \frac{kg_v}{kg_a} \cdot \dot{m}_{a2} = 4.53 \times 10^{-4} \frac{kg_v}{s}$

$\dot{m}_{v1} = \omega_1 \dot{m}_{a1} \Rightarrow \dot{m}_{v1} = 6.66 \times 10^{-4} \frac{kg_v}{s}$

$\dot{m}_{a3} = \dot{m}_{a2} + \dot{m}_{a1} = 0.1239 \frac{kg_a}{s}$

$\dot{m}_{v3} = \dot{m}_{v2} + \dot{m}_{v1} = 1.12 \times 10^{-3} \frac{kg_v}{s}$

$\omega_3 = \frac{1.12 \times 10^{-3} \ kg_v/s}{0.1239 \frac{kg_a}{s}} = 9.04 \times 10^{-3} \frac{kg_v}{kg_a}$

$\omega_3 = 0.622 \frac{p_{v3}}{p - p_{v3}} \Rightarrow \omega_3 p - \omega_3 p_{v3} = \ldots$

$\ldots = 0.622 \, p_{v3}$

$\Rightarrow \omega_3 p = (\omega_3 + 0.622) p_{v3} \Rightarrow$

$\Rightarrow p_{v3} = \frac{\omega_3}{\omega_3 + 0.622} p \Rightarrow p_{v3} = \frac{9.04 \times 10^{-3}}{9.04 \times 10^{-3} + 0.622} \times 1 \ bar$

$= p_{v3} = 0.014 \ bar$

$\phi_3 = \frac{p_{v3}}{p_{sat}(t_3)}$

$\dot{m}_{a1} h_a(t_1) + \dot{m}_{v1} h_g(t_1) + \dot{m}_{a2} h_a(t_2) + \dot{m}_{v2} h_g(t_2)$

$\ldots = \dot{m}_{a3} h_a(t_3) + \dot{m}_{v3} h_g(t_3) \Rightarrow$ ($\dot{m}_{a1} + \dot{m}_{a2} = \dot{m}_{a3}$)

$\dot{m}_{a1} h_a(t_1) - \dot{m}_{a1} h_a(t_3) + \dot{m}_{v1} h_g(t_1) + \ldots$

$\ldots + \dot{m}_{a2} h_a(t_2) - \dot{m}_{a2} h_a(t_3) + \dot{m}_{v2} h_g(t_2) = \ldots$

$\ldots = \dot{m}_{v3} h_g(t_3) \Rightarrow$

$\Rightarrow \dot{m}_{a1} c_p (t_1 - t_3) + \dot{m}_{v1} h_g(t_1) + \dot{m}_{a2} c_p (t_2 - t_3) + \ldots$

$\ldots + \dot{m}_{v2} h_g(t_2) - \dot{m}_{v3} h_g(t_3) = 0$

$0.041 \frac{kg_a}{s} \times 1.005 \frac{kJ}{kg_a K} \times (36 - t_3) + 6.66 \times 10^{-4} \frac{kg_v}{kg_a} \times \ldots$

$\ldots \times 2567.1 \frac{kJ}{kg} + 0.0829 \frac{kg_a}{s} \times 1.005 \frac{kJ}{kg_a K} \times (5 - t_3) + \ldots$

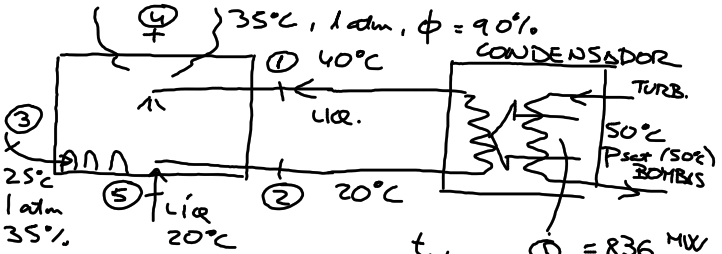
$\ldots + 4.53 \times 10^{-4} \frac{kg_v}{kg_a} \times 2510.6 \frac{kJ}{kg} - 1.12 \times 10^{-3} \frac{kg_v}{s} \times h_g(t_3) = 0$

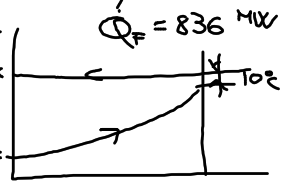
Si $t_3 = 20°C \rightarrow EQ. = 10$ (SUPONGAMOS) $\neq 0$

$t_3 = 25°C \rightarrow EQ = 20$ $\neq 0$

$t_3 = 15.5°C \Rightarrow p_{sat}(15.5°C) = 0.0176 \ bar$

$\phi_3 = \frac{p_{v3}}{p_{sat}(t_3)} = 0.79 \rightarrow 79\%$





CAUDAL SIN TORRE

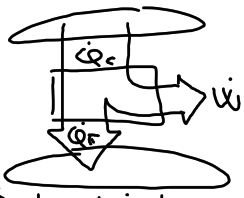
$\dot{Q}_F = \dot{m}_{ref}(h_s - h_e) \Rightarrow$

$\Rightarrow \dot{Q}_F = \left(\frac{\Delta C}{v}\right)_{ref} c\,(T_s - T_e) \Rightarrow$

$\Rightarrow (\Delta C)_{ref} = \frac{\dot{Q}_F v_{ref}}{c\,(T_s - T_e)} = \frac{\dot{Q}_F}{\rho c (T_s - T_e)} \Rightarrow$

$\Rightarrow (\Delta C)_{ref} = \frac{836\times10^3\ KW}{1000\ \frac{kg}{m^3} \times 4.186\ \frac{kJ}{kg\,K} \times 10\ K} \Rightarrow$

$\Rightarrow (\Delta C)_{ref} = 19.97\ \frac{m^3}{s} = 71892\ \frac{m^3}{h}$



$\eta = \frac{\dot{W}}{\dot{Q}_c} = 1 - \frac{|\dot{Q}_F|}{\dot{Q}_c} \Rightarrow$

$\dot{W} = \eta \dot{Q}_c \Rightarrow$

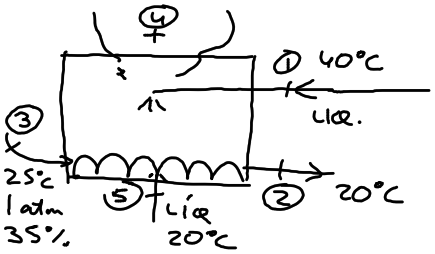
$\Rightarrow \dot{W} = 0.30\ \dot{Q}_c$

$\eta = 1 - \frac{|\dot{Q}_F|}{\dot{Q}_c} \Rightarrow \frac{|\dot{Q}_F|}{\dot{Q}_c} = 1 - \eta \Rightarrow \dot{Q}_c = \frac{|\dot{Q}_F|}{1-\eta}$

$\Rightarrow \dot{Q}_c = \frac{836\times10^3\ KW}{1 - 0.30} = 1194285\ KW$

$\dot{W} = 0.30 \times 1194285\ KW = 358285\ KW$

$\dot{W} = 358.285\ MW$



$\dot{m}_e = \dot{m}_s \Rightarrow \dot{m}_{a1} + \dot{m}_s + \dot{m}_{v3} = \dot{m}_{a2} + \dot{m}_{v4} \Rightarrow$

$\Rightarrow \dot{m}_s = \dot{m}_{v4} - \dot{m}_{v3}$

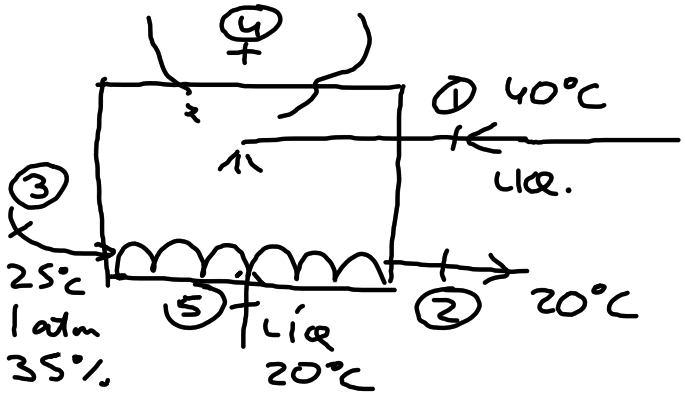
$\omega_4 = \frac{\dot{m}_{v4}}{\dot{m}_a} \Rightarrow \dot{m}_{v4} = \omega_4 \dot{m}_a,\ \dot{m}_{v3} = \omega_3 \dot{m}_a \Rightarrow$

$\Rightarrow \dot{m}_s = \dot{m}_a(\omega_4 - \omega_3)$

$\omega_4 = 0.622\ \frac{0.90 \cdot p_{sat}(35°C)}{1.013\ bar - 0.90\ p_{sat}(35°C)} = \ldots$

$\omega_3 = 0.00688\ \frac{kg_v}{kg_a} \ldots = 0.0327\ \frac{kg_v}{kg_a}$

$\dot{m}_3 = \dot{m}_a + \dot{m}_{v3} \Rightarrow \dot{m}_3 = \dot{m}_a(1 + \omega_3)$



$\dot{m}_e h_e = \dot{m}_s h_s \Rightarrow \dot{m}_1 h_1 + \dot{m}_a h_a(t_3) + \dot{m}_{v3} h_g(t_3) + \dots$ ($\dot{m}_{v3} = \omega_3 \dot{m}_a$)

$\dots + \dot{m}_s h_f(t_5) = \dot{m}_2 h_2 + \dot{m}_a h_a(t_4) + \dot{m}_{v4} h_g(t_4)$ ($\dot{m}_{v4} = \omega_4 \dot{m}_a$)

$$\dot{m}_1 = \dot{m}_2 = \frac{\dot{Q}_F}{h_1 - h_2} = \frac{836 \times 10^3 \text{ kW}}{4.186 \frac{\text{kJ}}{\text{kg K}} \times 20°\text{C}} = 10000 \frac{\text{kg}}{\text{s}}$$

$h_1 \cong h_f(40°C) = 167.6 \frac{\text{kJ}}{\text{kg}}$.

$h_2 \cong h_f(20°C) = 84 \frac{\text{kJ}}{\text{kg}}$

$h_a(25°C) = 298.18 \frac{\text{kJ}}{\text{kg}}$.

$h_g(25°C) = 2547.2$ kJ/kg

$h_f(20°C) = 84 \frac{\text{kJ}}{\text{kg}}$.

$h_a(35°C) = 308.23 \frac{\text{kJ}}{\text{kg}}$

$h_g(35°C) = 2565.3$ kJ/kg

CON

$\dot{m}_s = \dot{m}_a(\omega_4 - \omega_3)$

$\dot{m}_a = 11261 \frac{\text{kg}}{\text{s}}$.

$$\dot{m}_s = 11261 \frac{\text{kg}}{\text{s}} \times (0.0327 - 0.00688) \frac{\text{kg}_v}{\text{kg}_a}$$

$$\dot{m}_s = 290.8 \frac{\text{kg}}{\text{s}} \sim 0.30 \frac{\text{m}^3}{\text{s}}$$