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Ans 1 Steam doesn't condense → T = 100°C

Now, $m_{cw}(h_{15}) + m_{st}(h_{300}) = m_{cw}(h_{75}) + m_{st}(h_{sat})$

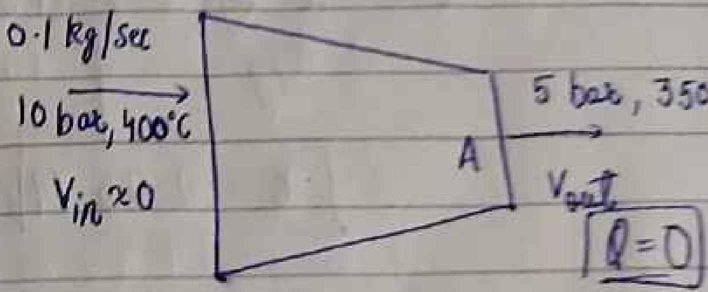
$T_{sat} = 151.86°C$

$\Rightarrow (h_{15} - h_{75}) = \frac{m_{st}}{m_{cw}}(h_{151.86} - h_{300})$

$\Rightarrow (62.94 - 313.94) = \frac{m_{st}}{m_{cw}}(2747.7 - 3064.2)$

$\Rightarrow \boxed{\frac{m_{st}}{m_{cw}} \approx 0.793}$

Ans 2



$\Rightarrow m_{in}(h_{in}) = m_{out}\left(h_{out} + \frac{V_{out}^2}{2}\right)$

$\Rightarrow V_{out} = \sqrt{2(h_{in} - h_{out})}$

$\Rightarrow V_{out} = \sqrt{2(3263.88 - 3167.65) \times 10^3}$

$\Rightarrow \boxed{V_{out} \approx 438.7 \text{ m sec}^{-1}}$

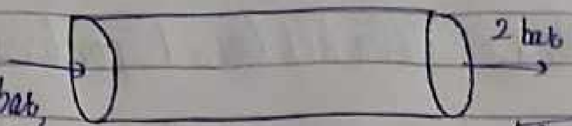
Now, $\frac{V_{out} A}{V_{specific}} = 0.1$

$\Rightarrow \frac{(438.7)(A)}{0.57652} = 0.1$

$\Rightarrow \boxed{A \approx 1.3 \text{ cm}^2}$

Ans 3

~~$v_{in} = 0.0010906$~~



$P = 15$ bar,
$T = 150°C$

$\boxed{Q = 0}$

$v_1 = 0.0010906$

For calculating state, neglect KE

$\Rightarrow h_{in} = h_{out}$

$\Rightarrow h_{in} = 632.15$

At 2 bar, $h_f = 504.7$

$h_g = 2706.4$

$\therefore h_f < h < h_g \longrightarrow$ Mixture

$$x = \frac{h - h_f}{h_{fg}} = \frac{632.15 - 504.7}{2201.7}$$

$$\Rightarrow \boxed{x = 0.0579}$$

Also, $\rho_1 A V_1 = \rho_2 A V_2$

$$\Rightarrow \frac{m}{v_1} \cdot V_{in} = \frac{m}{v_2} V_{out}$$

$$\Rightarrow V_{out} = \left(\frac{v_2}{v_1}\right) V_{in}$$

Now, $v_2 = v_f + x v_{fg} = (0.001061) + (0.0579)(0.884969)$

$v_2 = 0.0523$

$$\therefore V_{out} = \left(\frac{0.0523}{0.0010906}\right) \times 5 \Rightarrow \boxed{V_{out} \approx 240 \text{ m sec}^{-1}}$$

Ans 4 $\cancel{Q}^{\,0} - W = h_{out} - h_{in} + \frac{\cancel{V_{out}^2}^{\,0} - V_{in}^2}{2}$

$\Rightarrow \boxed{W = h_{in} - h_{out} + \frac{V_{in}^2}{2}}$

~~Now, $h_{in} - h_{out} = (u_{in} - \cancel{u_{out}}^{\,0}) + \Delta PV$~~

~~$\Rightarrow h_{in} - h_{out} = v(\Delta P)$~~
~~$= (0.00100171)(2000 - 100)$ kJ/kg~~
~~$\Rightarrow h_{in} - h_{out} \approx 1.9$ kJ/kg~~

Now, $h_{in} = 85.82$ kJ/kg
$h_{out} = 83.94$ kJ/kg

$\therefore h_{in} - h_{out} = 1.88$ kJ/kg

$\therefore W = 1.88 + \left(\frac{(15)^2 \times 10^{-3}}{2}\right)$

~~$\boxed{W \approx 2.01 \text{ kJ/kg}}$~~ $\Rightarrow \boxed{W \approx 1.9925 \text{ kJ/kg}}$

$\therefore$ ~~$P = \dot{m}W = (2)(2.01)$~~ ~~$\boxed{P \approx 4 \text{ kW}}$~~

$P = \dot{m}W$
$= (2)(1.9925)$
$\boxed{P \approx 3.985 \text{ kW}}$

Ans 5

15°C
1 bar

1 bar
d = 1cm

P = 1 kW

Now, $\boxed{\frac{P}{\dot{m}} = W}$

$\Rightarrow \cancel{Q}^{\,0} + W = (h_{out} - h_{in}) + \frac{V_{out}^2}{2} - \frac{V_{in}^2}{2}$

Also, $h_{in} = h_{out}$ $(\because \Delta h = v(\Delta P) = 0)$

$\therefore$ $W = \frac{V_{out}^2}{2} - \cancel{\frac{V_{in}^2}{2}} \rightarrow 0$

$\Rightarrow$ $\boxed{W = \frac{V_{out}^2}{2}}$

Also, $\dot{m} = \frac{(Area)(v)}{V}$

$\dot{m}W = P$

$\Rightarrow \left[\frac{(\pi d^2)}{4}\frac{(v)}{V}\right]\left[\frac{v^2}{2}\right] = P$

$\Rightarrow v = 2\left(\frac{PV}{\pi d^2}\right)^{1/3}$

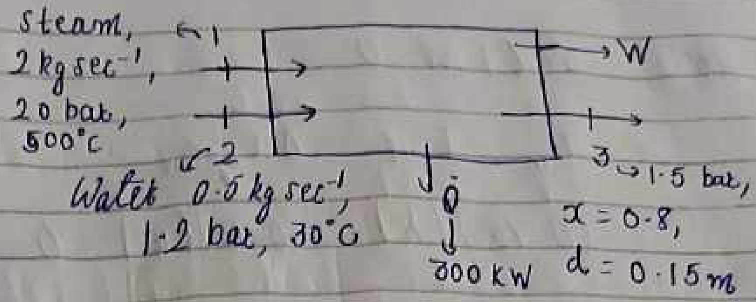
$\Rightarrow v = 2\left[\frac{10^3 \times 0.0010008}{(3.14)(0.01)^2}\right]^{1/3}$

$\Rightarrow \boxed{v \approx 29.43\ m\,sec^{-1}}$

$\therefore$ $\dot{m} = \left(\frac{\pi d^2}{4}\right)\frac{(v)}{V}$

$\Rightarrow \boxed{\dot{m} = 2.308\ kg\,sec^{-1}} \approx \boxed{2.31\ kg\,sec^{-1}}$

Ans. 6



$$\Rightarrow \boxed{\dot{m}_2\left(h_1 + \cancel{\frac{v^2}{2}}^{\,0}\right) + \dot{m}_1\left(h_2 + \cancel{\frac{v^2}{2}}^{\,0}\right) = \dot{Q} + \dot{W} + \dot{m}_3\left(h_3 + \frac{v^2}{2}\right)} \quad -(1)$$

Also, $\dot{m}_1 + \dot{m}_2 = \dot{m}_3$ | $h_3 = 467.2 + (0.8)(2226.3)$

$\Rightarrow h_3 = 2248.24$

$$\Rightarrow \dot{m}_3 = 2.5\ \text{kg sec}^{-1} = \frac{Av}{v_{sp}}$$

$$\Rightarrow 2.5 = \frac{(\pi)(0.15)^2}{4}\frac{(v)}{(0.926613)}$$

$$\Rightarrow \boxed{v \approx 131.2\ \text{m sec}^{-1}}$$

∴, Using eqⁿ (1):

$$(2)(3467.55) + (0.5)(125.66) = 300 + P + (2.5)\left(2248.24 + \frac{(131.2)^2}{2\times10^3}\right)$$

$$\Rightarrow P \approx 1055.8132$$

$$\Rightarrow \boxed{P \approx 1056\ \text{kW}}$$

Ans 7 $Q = 0,\ W = 0$

$\Rightarrow E_{in} - E_{out} = \Delta E_{system}$

$\Rightarrow (0.75)(h) = (0.75)(u_2) - 0$

$\Rightarrow \boxed{u_2 = h = \cancel{3}\,3161.68}$

At 8 bar, $u_f = 720.41$, $u_g = 2575.73$

$\therefore$ $u > u_g \rightarrow$ superheated steam

At $T = 500°C \rightarrow \cancel{3}\ u = 3125.95$
$T = 600°C \rightarrow u = 3297.91$

$$\Rightarrow \frac{T - 500}{600 - 500} = \frac{3161.68 - 3125.95}{3297.91 - 3125.95}$$

$$\Rightarrow \boxed{T \approx 520.778°C}$$

At $T = 500° \rightarrow V_{sp} = 0.4431$
$T = 600° \longrightarrow V_{sp} = 0.50184$

$$\therefore \frac{V - 0.44331}{0.50184 - 0.44331} = \frac{520.778 - 500}{600 - 500}$$

$$\Rightarrow \boxed{V_{sp} = 0.4555\ m^3/kg}$$

$$\therefore \boxed{V = (m\, V_{sp}) \approx 0.342\ m^3}$$

Ans 8 $\Delta E_{system} = E_{in} - E_{out}$

$\Rightarrow m_2 u_2 - m_1 u_1 = Q_{in} - m_{out}(h)$

$V_1 = 0.1 m^3$, $P_1 = 10$ bar, $T_1 = 200°C$

$V_2 = 0.1 m^3$, $P_2 = 1$ bar, $T_2 = 50°C$

$\Rightarrow PV = mRT$

$$\Rightarrow m_1 = \frac{P_1 V_1}{R T_1} = \frac{(10^3)(0.1)}{(0.287)(473)} = 0.736 \text{ kg}$$

$$\Rightarrow m_2 = \frac{P_2 V_2}{R T_2} = \frac{(100)(0.1)}{(0.287)(323)} = 0.1078 \text{ kg}$$

$$\Rightarrow h = \left(\frac{h_1 + h_2}{2}\right)$$ [assuming h falls linearly with mass]

$$= \frac{C_p (T_1 + T_2)}{2} = (1.005)\left[273 + \left(\frac{250}{2}\right)\right]$$

$$\boxed{h = 399.99 \text{ kJ/kg}}$$

$$\Rightarrow Q_{in} = m_2 u_2 - m_1 u_1 + m_{out} h_{out}$$

$$= (0.1078)(0.718)(323) - (0.736)(0.718)(473) + (0.736 - 0.1078)(399.99)$$

$$\boxed{Q_{in} \approx 26.32 \text{ kJ}}$$

Ans.9 $V = 1 m^3$

air $\rightarrow$ 5 bar, 20°C

$PV = mRT$

$\Rightarrow (500)(1) = (m_1)(0.287)(293)$

$\Rightarrow \boxed{m_1 = 5.946 \text{ kg}}$

finally, 15 bar, 35°C,

$m_2 = \frac{(1500)(1)}{(0.287)(308)} = 16.97 \text{ kg}$

Now, $(m_{in})(h_{in}) + Q_{in} = \Delta E_{system}$

$\Rightarrow (16.97 - 5.946)(1.005 \times 293) + Q_{in} = (16.97)(0.718)(308) - (5.946)(0.718)(293) + (40)(C)(15)$

Take, $C = 0.466$ kJ/kg°C

$\therefore Q_{in} = (40)(0.466)(15) - 744.25$

$\boxed{Q_{in} \approx -464.65 \text{ kJ}}$

Ans.10 $V = 0.2 m^3$

1 bar, $x = 0.01$

$v_{sp} = v_f + x v_{fg} = (0.001043) + (0.01)(1.67596)$
$= 0.0178 \text{ m}^3/\text{kg}$

$\Rightarrow \boxed{m_1 = 11.236 \text{ kg}}$

Finally, 20 bar, $x = 0.9$

$\therefore v_{sp} = 0.001176 + (0.9)(0.09819)$
$= 0.089547$

$\Rightarrow \boxed{m_2 = 2.3334 \, kg}$

$\therefore \boxed{\Delta m = 8.90 \, kg}$

$\rightarrow E_{in} - E_{out} = \Delta E_{system}$

$\Rightarrow Q_{in} - (\Delta m)(h_{out}) = m_2 u_2 - m_1 u_1$

Now, $u_2 = (906.25) + (0.9)(1692.52)$
$= 2429.52 \, kJ/kg$

$u_1 = (417.9) + (0.01)(2090.44)$
$= 438.8 \, kJ/kg$.

$h_{out} = 2797.5 \, kJ/kg$

$\therefore Q_{in} = (2.3334)(2429.52) - (11.236)(438.8) + (8.90)(2797.5)$

$\boxed{Q_{in} \simeq 25.63 \, MJ}$