Refrigeration and Air conditioning HomeWork 2

Answers table

Question 2.1	a	Subcooled
	b	0.0375 Kg/S
Question 3.5	a	31.81 °C
	b	0.25 Kg/S
Question 3.6	a	-89.02 KW
	b	-0.01 Kg/S
Question 3.9		16°C, 14°C
Question 4.4	a	681.5 W
	b	-384.22
Question 6.3		0.7 Pa/m
Question 6.5		9.38 m

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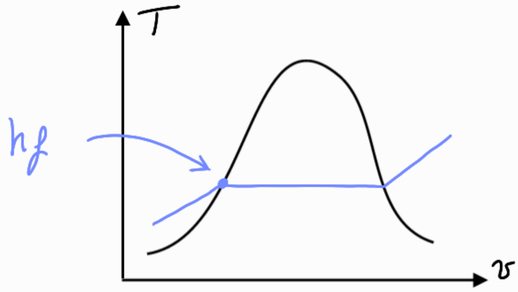
Question 2.1

a) Subcooled liquid since $T < T_{sat}$ at 250 KPa

b) From table B.1.1 and at T = 120°C

$h_{water} = h_f = 503.69$ KJ/Kg



The expansion valve changes the pressure and temperature But enthalpy is constant so: $h_{inlet} = h_{tank} = 503.69$ KJ/Kg

The tank has a mixture of vapor and liquid with a Quality of x at P = 101.3 KPa So:

$$h = h_f + x(h_{fg})$$

503.69

$h_f = 419.02$
$h_g = 2257.03$ } at P = 101.3 KPa

$$503.69 = 419.02 + x(2257.03)$$

$$x = 0.0375 = \frac{m_{vap}}{m_{tot}}$$

$m_{tot} = 1$ Kg so $x = (m_{vap})(1) = m_{vap} = 0.0375$

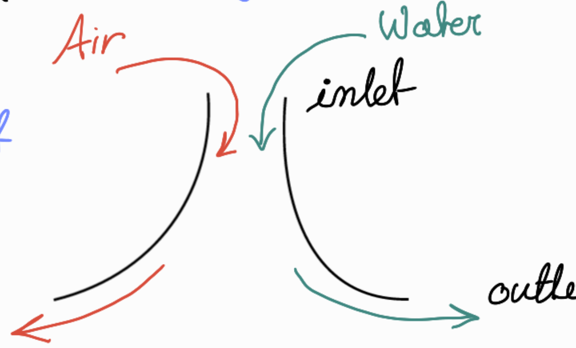
entering the tank from valve

Question 3.5

a)

$$(\Sigma \dot{m} h)_{inlet} = (\Sigma \dot{m} h)_{outlet}$$

$$(\dot{m}_i h_i)_{air} + (\dot{m}_i h_i)_{water} = (\dot{m}_o h_o)_{air} + (\dot{m}_o h_o)_{water} \quad (1)$$



$$\dot{m}_i = \rho \dot{V}_i = \frac{1}{v} \dot{V}_i$$

$h_i = 72$ KJ/Kg
$v = 0.892$ m³/Kg
} from psychrometric chart

$$\dot{m}_i = \frac{1}{0.892} \times 15 = 16.82 \text{ Kg/s}$$

For the water:

From steam tables and by interpolation h_f of water is:

$X = 38 \qquad y = ?$

$X_1 = 35 \qquad y_1 = 146.66$

$X_2 = 40 \qquad y_2 = 167.54$

$$\frac{X - X_1}{y - y_1} = \frac{X_2 - X_1}{y_2 - y_1} \longrightarrow y = 159.2 = h_f$$

- To find h_o for air

We Know that $T_{sat} = 31$

▶ from psychrometric chart, $(h_o)_{air} = 110$ KJ/Kg

Go Back to equation 1

$$(\dot{m}_i h_i)_{air} + (\dot{m}_i h_i)_{water} = (\dot{m}_o h_o)_{air} + (\dot{m}_o h_o)_{water}$$

$$(16.82)(72) + (20)(159.2) = (16.82)(110) + (20)(h_o)$$

$$(h_o)_{water} = 127.24 \text{ KJ/Kg}$$

But $h = C_p T \longrightarrow 127.24 = 4 \times T \longrightarrow T_{water} = 31.81°C$

b) humidity ratio $= \Delta\omega = \dfrac{(\dot{m}_w \text{ vapor})_{process}}{(\dot{m} \text{ dry air})_{process}}$

$\dot{m}$ vapor $= \dot{m}$ dry air $\Delta\omega$

$= 16.82\,(\omega_{outlet} - \omega_{inlet})$

← psychrometric chart

$\omega_{inlet} = 0.013$ kg/kg

$\omega_{outlet} = 0.028$ kg/kg

$\dot{m}$ vapor $= 0.25$ kg/s

Question 3.6

a) $Q = \dot{m} \Delta h$

Inlet Conditions

$T_{dry\ bulb} = 27°C$

Relative humidity = 50%

From psychrometric chart

$h = 56$ KJ/Kg

$\omega = 0.011$ Kg/Kg

$v = 0.865$

Outlet Conditions

$T_{dry\ bulb} = 13°C$

Relative humidity = 90%

From psychrometric chart

$h = 34$ KJ/Kg

$\omega = 0.0085$ Kg/Kg

$$Q = \dot{m} \Delta h = \frac{3.5}{0.865}(34 - 56) = -89.02 \text{ KW}$$

b) $\dot{m}_{vapor} = \Delta \omega \ \dot{m}_{dry\ air}$

$$= (0.0085 - 0.011) \times \frac{3.5}{0.865} = -0.01 \text{ Kg/s}$$

↳ Condensation

Question 3.9

$$(\Delta\omega)_{process} = \frac{\dot{m}\ vapor}{\dot{m}\ dry\ air}$$

$$= \frac{0.0025}{0.36} = 6.94 \times 10^{-3} = \omega_{outlet} - \omega_{inlet}$$

At inlet and from psychrometric chart

$T_{dry} = 15°C$

Relative humidity = 20%

$\omega_i = 0.002$ Kg/Kg , $h = 20$ KJ/Kg

So $\omega_{outlet} = 6.94 \times 10^{-3} + 2 \times 10^{-3} = 8.94 \times 10^{-3}$ Kg/Kg

$$\Sigma(\dot{m} h)_{inlet} = \Sigma(\dot{m} h)_{outlet}$$

$$(\dot{m}_i h_i)_{steam} + (\dot{m}_i h_i)_{air} = (\dot{m}_o h_o)_{air}$$

$$(0.0025) \times (2676.05) + (0.36)(20) = (0.0025 + 0.36)(h_{air})$$

steam tables (→ 2676.05)

$h_{air_o} = 38.3$ KJ/Kg

From psychrometric chart

$T_{dry} = 16°C$

$T_{wet} = 14°C$

Question 4.4

Room Area = 10 x 7 m^2

Exterior wall : height = 3.5 high , length = 10 m

Steel backed with 10 mm of insulating board, 75 mm of glass fiber and 16 mm of gypsum board.

Single glazed window → 30% of exterior wall

Computer and lights → 24 h/d → Q = 2 kW

T indoor = 20°C

a) Columbus, Ohio → heating load at winter?

$$Q_{winter} = Q_{transition} + - Q_{equipement}$$
$$= (UA\Delta T)_{wall} + (UA\Delta T)_{window} - 2\text{ kW}$$

$$U_{wall} = \frac{1}{\Sigma R} = \frac{1}{L_1/k_1 + L_2/k_2 + L_3/k_3}$$

$$= \frac{1}{0.32 + 0.1 + \frac{0.075}{0.044}} = 0.47$$

0.32 ← insulation Board; 0.1 ← Gypsum; $\frac{0.075}{0.044}$ ← fiber Glass

A (External wall) = 3.5 x 10 = 35 m^2 − A window

A (window) = $\frac{30}{100}$ x 35 = 10.5

A (wall) = 35 − 10.5 = 24.5

$\Delta T = T_{out} - T_{in} = T_{out} - 20 = -35$

From Table 4-3

$= -15$

$U_{window} = 6.2$ (Table 4-4)

$\Delta T = -35$

So $Q_{window} = 6.2 \times 10.5 \times 35 = 2278.5$

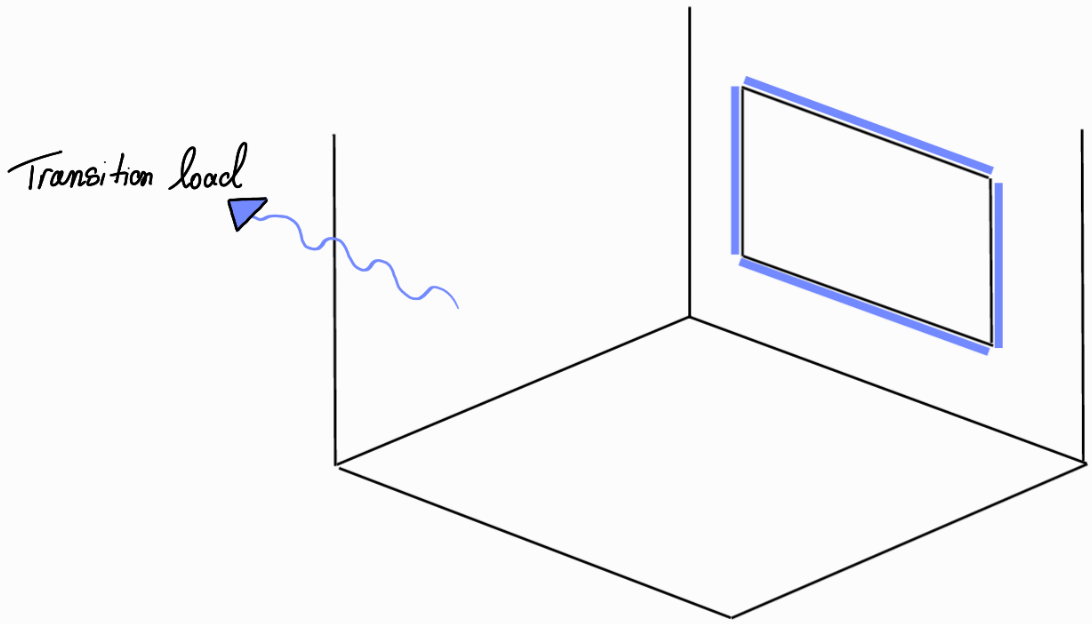
$Q_{wall} = 0.47 \times 24.5 \times 35 = 403.03$

$Q_{heating} = 2278.5 + 403.03 - 2000 = 681.5$ W

b) $Q_{window} = 3.3 \times 10.5 \times 35 = 1212.75$

$Q_{heating} = 1212.75 + 403.03 - 2000 = -384.22$ KW

- So no need for heating since equipement load > heating load



Question 6.3

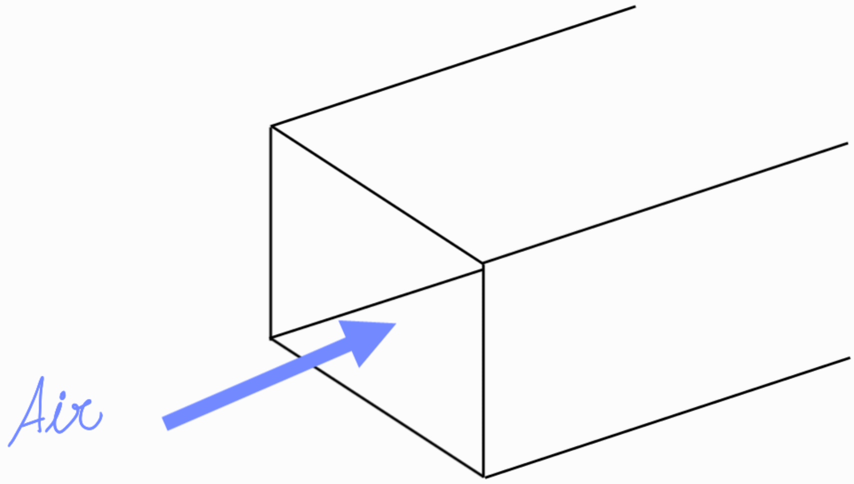
Rectangular Duct $0.25 \times 1m$

$\dot{V} = 1.2 \ m^3/s$

$$D_{eq} = \frac{4 \times Area}{perimeter} = \frac{2ab}{a+b} = \frac{2 \times 0.25 \times 1}{1+0.25} = 0.4$$

$$velocity = \frac{1.2}{Area} = \frac{1.2}{0.25 \times 1} = 4.8 \ m/s$$

pressure drop / meter $= 0.7$ Pa/m



Question 6.5

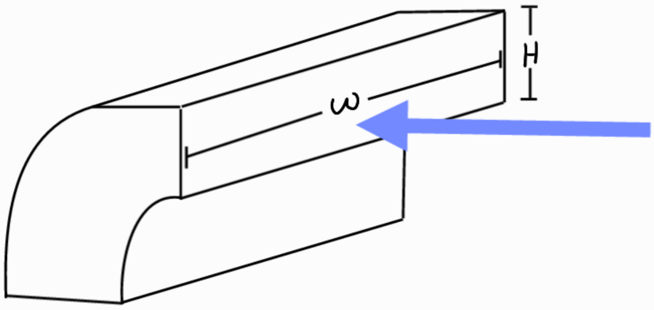
A duct : 0.4 X 0.8 $\longrightarrow D_h = \frac{2ab}{a+b} = \frac{2 \times 0.4 \times 0.8}{0.8+0.4} = 0.533$

inner radius = 0.2 m

outer radius = 1 m

velocity = 10 m/s

$L_{eq} = ?$



From Fig 6-8

$\frac{inner}{outer} = \frac{0.2}{1} = 0.2$

$\frac{W}{H} = \frac{0.8}{0.4} = 2$

$\frac{P_{loss}}{V^2 \frac{\rho}{2}} = 0.3$

$P_{loss} = 0.3 \times (10)^2 \times \frac{1.25}{2} = 18.75$

Pressure drop /meter = 2 Pa/m

$L_{eq} = \frac{P_{loss}}{Pa/m} = \frac{18.75}{2} = 9.375\, m$