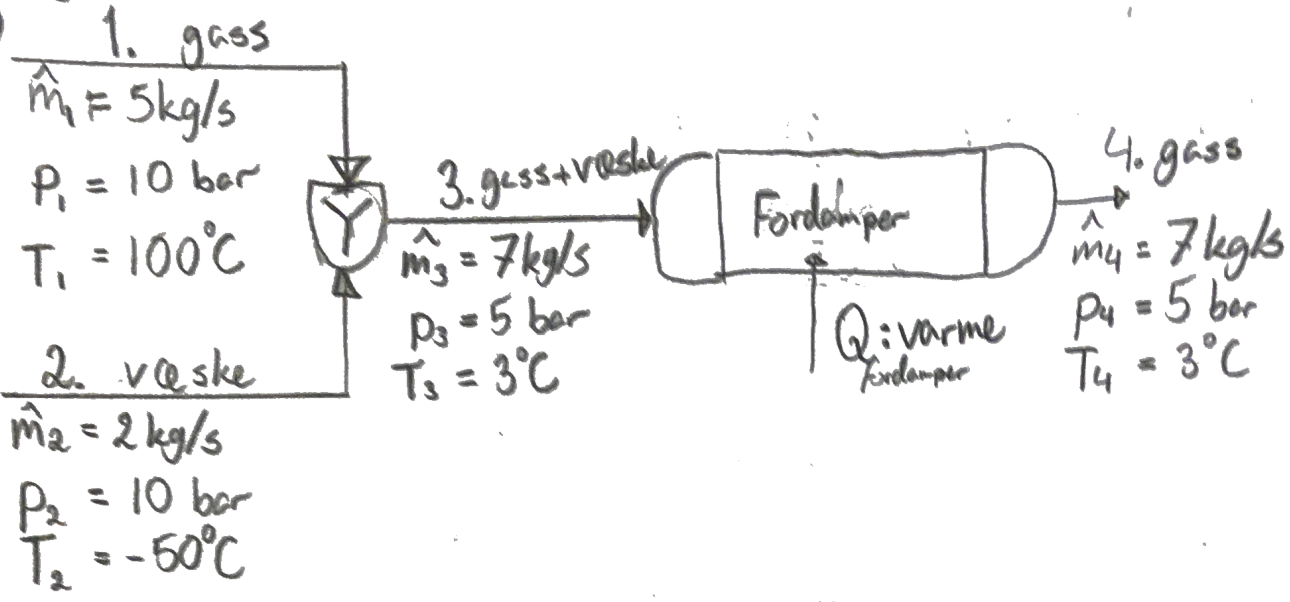
Prosessteknikk - Øving 8

Oppgave 1:

a)



b) Blander: $\hat{m}_3 = \hat{m}_1 + \hat{m}_2 = 7\ kg/s$

Energibalanse: $\Delta H = 0 = H_{ut} - H_{inn} = H_3 - H_1 - H_2 = 0$

$\Rightarrow \hat{m}_3 h_3 - \hat{m}_2 h_2 - \hat{m}_1 h_1 = 0$

Absolutte entalpier; Velger $NH_3(l)$ v/ $T = 3°C$ som referanse.

$$h_1 = \Delta H_{vap}(NH_3) + \int_{T_3}^{T_1} C_{p,g}\, dT = 1250\ kJ/kg + 2\ kJ/(kg \cdot K)(100-3)\cdot K$$

$$= \underline{1444\ kJ/kg}$$

$$h_2 = \int_{T_3}^{T_2} C_{p,l}\, dT = 4{,}6\ kJ/(kg \cdot K) \cdot (-50-3)K = \underline{-243{,}8\ kJ/kg}$$

Lar væskefraksjonen være V_f

da er $h_3 = V_f \cdot h_3(l) + (1-V_f) h_3(g)$

$h_3(l) = 0$ (referanse)

$h_3(g) = \Delta h_{vap}(NH_3)$

(fra væske til gass $\Delta T = 0$)

$h_3 = (1 - V_f)\, 1250\ kJ/kg$

Setter h_1, h_2 og h_3 inn i energibalansen:

$$7\ kg/s \cdot (1-V_f)\,1250\ kJ/kg - 2\ kg/s\,(-243{,}8\ kJ/kg) - 5\ kg/s\,(-144\ kJ/kg) = 0$$

$$8750\ kJ/s\,(1-V_f) = 6732{,}4\ kJ/s$$

$$1-V_f = 0{,}769$$

$$\underline{V_f = 0{,}231}$$

Delprosessmetoden: Deler inn prosessen i 3 delprosesser:

1) Avkjøling av $\hat{m}_1$ til 3°C:

$$q_1 = \hat{m}_1 \cdot \int_{T_1}^{T_3} c_{p,g}\,dT = \hat{m}_1 \cdot c_{p,g}\,(T_3 - T_1)$$
$$= 5\ kg/s \cdot 2\ kJ/(kg\cdot K)\,(3-100)\,K$$
$$= \underline{-970\ kJ/s}$$

2) Oppvarming av $\hat{m}_2$ til 3°C:

$$q_2 = \hat{m}_2 \cdot \int_{T_2}^{T_3} c_{p,l}\,dT = \hat{m}_2 \cdot c_{p,l} \cdot (T_3 - T_2)$$
$$= 2\ kg/s \cdot 4{,}6\ kJ/(kg\cdot K) \cdot (3+50)\,K$$
$$= \underline{487{,}6\ kJ/s}$$

3) Fordamping av $NH_3(l)$ til $NH_3(g)$, kun en delmengde k av $\hat{m}_3$

$$q_3 = k \cdot \Delta H_{vap} = k \cdot 1250\ kJ/kg$$

Ved energibalanse: $q_1 + q_2 + q_3 = 0$

$$-970\ kJ/s + 487{,}6\ kJ/s + 1250\ kJ/kg \cdot k = 0$$

$$\underline{k = 0{,}386\ kg/s}$$

$$\hat{m}^3_{væske} = \hat{m}_2 - k = \underline{1{,}614\ kg/s} \Rightarrow *$$

$$* V_f = \frac{\hat{m}^3_{væske}}{\hat{m}_3} = 0{,}231$$

$$\underline{V_f = 0{,}231}$$

c) $Q_{fordamper} = \Delta H_{fordamper} = \hat{H}_4 - \hat{H}_3$

$= \hat{m}^3_{væske} \cdot \Delta H_{vap}(NH_3)$

$= 1{,}614\ kg/s \cdot 1250\ kJ/kg$

$Q_{fordamper} = 2017{,}5\ kJ/s = 2017{,}5\ kW$

$\underline{Q_{fordamper} = 2017{,}5\ kW}$

Oppgave 2:

a) - Gjort i oppgave 1

b) Absolutt entalpi Vet at: $\hat{m}_3 = \hat{m}^3_{gass} + \hat{m}^3_{væske}$ (I)

$\hat{m}^3_{væske} = v_f \cdot \hat{m}_3$ (II)

Fr... $\hat{m}_3 h_3 = \hat{m}^3_{væske} \cdot h_3(l) + \hat{m}^3_{gass} \cdot h_3(g)$ (III)

I og II inn i III: $\hat{m}_3 h_3 = \hat{m}_3(v_f \cdot h_3(l) + (1-v_f) \cdot h_3(g))$ (IV)

(hadde denne i oppg 1 også)

Energibalanse: $\hat{m}_3 h_3 = \hat{m}_1 h_1 + \hat{m}_2 h_2$

$\hat{m}_3 (v_f \cdot h_3(l) + (1-v_f) h_3(g)) = 5\ kg/s \cdot h_1 + 2\ kg/s \cdot h_2$

$p_1 = 10\ bar = 1\ MPa$
$p_2 = 10\ bar = 1\ MPa$
$p_3 = 5\ bar = 0{,}5\ MPa$

Leser av fra diagrammet:

h_1	$= 720\ kJ/kg$
h_2	$= -980\ kJ/kg$
$h_3(l)$	$= -760\ kJ/kg$
$h_3(g)$	$= 500\ kJ/kg$

Setter inn verdier, får $\underline{v_f = 0{,}213}$

Delprosess: Samme delprosesser som i oppgave 1
Gir akkurat samme utregninger som i 1)

c) All væske i $\hat{m}_3$ fordampes $\Rightarrow Q_{fordamp} = H_4 - H_3$

$= V_f (h_3(g) - h_3(l)) \cdot \hat{m}_3$

$= 0{,}213\,(500 - (-760))\ \text{kW}$

$= 1878{,}7\ \text{kW}$

$\underline{Q_{fordamper} = 1878{,}7\ \text{kW}}$