Øving 9 - Prosessteknikk

Oppgave 1: a) Idell gass $\Rightarrow pV = nRT \Rightarrow \Delta V = \frac{nRT}{\Delta p}$

$$\Rightarrow W_s^{rev} = -\int_{p_0}^{p_f} \Delta V \, dp = nRT \ln\left(\frac{p_f}{p_0}\right)$$

$$= 50 \cdot 8{,}314 \cdot 300 \cdot \ln\left(\frac{30}{3}\right)$$

$$= 287155 \text{ W} = 287 \text{ kW}$$

$$W_s = \frac{W_s^{rev}}{\text{Virkningsgrad}} = \frac{287155 \text{ W}}{0{,}7} = 410221 \text{ W} = 410 \text{ kW}$$

$$\underline{W_s = 410 \text{ kW}}$$

b) Samme fremgangsmåte som a), ny $T = 400 \text{ K}$

$$\Rightarrow \underline{W_s = 547 \text{ kW}}$$

Oppgave 2:

c) Vet at $pV^{\gamma} =$ konstant for prosessen

$$\Rightarrow \frac{T_f}{T_0} = \left(\frac{p_f}{p_0}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{p_f}{p_0}\right)^{\frac{R}{c_p}}$$

$$\Rightarrow T_f = T_0 \left(\frac{p_f}{p_0}\right)^{\frac{R}{c_p}}$$

Beregner for trinn 1:

$$T_1 = 558{,}4 \text{ K}$$

$$W_s^{Rev} = n \cdot c_p \cdot \Delta T = 50 \cdot 30 \cdot (558{,}4 - 400) \text{ W}$$

$$= \underline{237{,}6 \text{ kW}}$$

$$\underline{W_s = \frac{W_s^{Rev}}{\text{Virkningsgrad}} = 339{,}5 \text{ kW}}$$

Trinn 2: Gassen kjøles til 400K = T_3

Beregner for Trinn 3: / Tilstand 4:

$$T_4 = T_3\left(\frac{30}{10}\right)^{R/c_p} = \underline{542,4\ K}$$

$$W_s^{rev} = n \cdot c_p \cdot \Delta T = 50 \cdot 30\,(542,4 - 400)\ W$$
$$= \underline{213,5\ kW}$$

$$W_s^3 = \frac{W_s^{rev}}{0,7} = \underline{305,0\ kW}$$

Totalt: $W_s^{tot} = W_s' + W_s^3 = 339,5\ kW + 305,0\ kW = 644,5\ kW$

$$\underline{\underline{W_s^{tot} = 644,5\ kW}}$$

d) Fra energibalanse

$$W_s^3 = n \cdot c_p \cdot \Delta T = n \cdot c_p (T - 400)$$

$$\Rightarrow T = \frac{W_s^3}{c_p \cdot n} + 400$$

$$\underline{\underline{T = 603,3\ K}}$$

e) Varmevekslingen av vannet er gitt ved massen, varmekapasitet på intervallet $Q = m_{H_2O} \int_{T_0}^{T} c_{p,H_2O}\, dT$

Videre skal temperaturen kjøles ned til temp før trinn 1

$$\Rightarrow Q = W_s' = 339,5\ kW = m_{H_2O} \cdot c_{p\,H_2O}\,(400 - 300)$$

$$\Rightarrow \underline{m_{H_2O} = 0,812\ kg/s}$$

se neste side

Finner temp tilstand 2 (etter trinn 1) slik som i d)

$\Rightarrow T = 626,3\,K$

Vet at $Q = U \cdot A \cdot \Delta T_{lm}$ der $\Delta T_{lm} = \dfrac{\Delta T_2 - \Delta T_1}{\ln\left(\frac{\Delta T_2}{\Delta T_1}\right)}$

der $\Delta T_1 = T_{gass}^{inn} - T_{H_2O}^{ut} = 226,3K$

$\Delta T_2 = T_{gass}^{ut} - T_{H_2O}^{inn} = 100\,K$

$\Rightarrow \Delta T_{lm} = \underline{159,6\,K}$

$\Rightarrow A = \dfrac{Q}{U \cdot \Delta T_{lm}} = \dfrac{W_s'}{U \cdot \Delta T_{lm}}$

$\Rightarrow A = 10,98\,m^2$

$\underline{\dot{m}_{H_2O} = 0,812\,kg/s\,,\ A = 10,97\,m^2}$