

Øving 9 - Prosesseteknikk

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

$$\begin{aligned}\Rightarrow W_s^{\text{rev}} &= - \int_{p_0}^{p_f} \Delta V dp = nRT \ln\left(\frac{p_f}{p_0}\right) \\ &= 50 \cdot 8,314 \cdot 3001 \cdot \ln\left(\frac{30}{3}\right) \\ &= 287155 \text{ W} = 287 \text{ kW}\end{aligned}$$

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

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

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

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

Oppgave 2:

c) Vel at pV^γ konstant for prosessen

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

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

Beregn for trinn 1:

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

$$\begin{aligned}W_s^{\text{rev}} &= n \cdot C_p \cdot \Delta T = 50 \cdot 30 \cdot (558,4 - 400) \text{ W} \\ &= \underline{237,6 \text{ kW}}\end{aligned}$$

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

Trinn 2: Gassen kjøles til $400\text{ K} = T_3$

Beregn for Trinn 3/Tilstand 4:

$$T_4 = T_3 \left(\frac{p_4}{p_3} \right)^{\gamma/c_p} = \underline{542,4\text{ K}}$$

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

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

$$\text{Totalt: } W_s^{\text{tot}} = W_s^1 + W_s^3 = 339,5\text{ kW} + 305,0\text{ kW} = 644,5\text{ kW}$$

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

d) Fra energibalansen

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

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

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

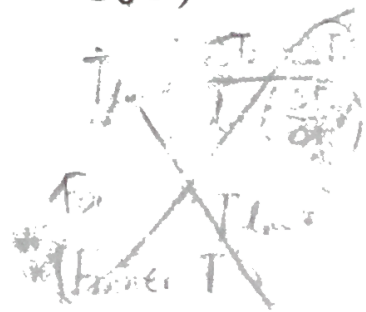
e) Narmvekslingen i vannet er gitt ved massen, varmeledning på intervallet $Q = m_{\text{H}_2\text{O}} \int_{T_0}^T c_{p,\text{H}_2\text{O}} dT$

Videre skal temperaturen kjøles ned til temp for trinn 1

$$\Rightarrow Q = W_s^1 = 339,5\text{ kW} = m_{\text{H}_2\text{O}} \cdot c_{p,\text{H}_2\text{O}} (400 - 300)$$

$$\Rightarrow \underline{m_{\text{H}_2\text{O}} = 0,812\text{ kg/s}}$$

se neste side



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

$$\Rightarrow T = 626,3 \text{ K}$$

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

der $\Delta T_1 = T_{\text{gass}}^{\text{inn}} - T_{\text{H}_2\text{O}}^{\text{ut}} = 226,3 \text{ K}$
og $\Delta T_2 = T_{\text{gass}}^{\text{ut}} - T_{\text{H}_2\text{O}}^{\text{inn}} = 100 \text{ K}$

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

$$\Rightarrow \Delta T_{\text{lm}} = \underline{154,6 \text{ K}}$$

$$\Rightarrow A = 10,96 \text{ m}^2$$

$$\underline{\underline{\dot{m}_{\text{H}_2\text{O}}} = 0,812 \text{ kg/s}, A = 10,97 \text{ m}^2}$$