Prosess 9

Oppg 1a)

$$W_s^{rev} = \int_{P_0}^{P_1} V \, dP$$

$$W_s = \frac{W_s^{rev}}{\mu}, \quad \mu = 0,7$$

$$V = \frac{nRT}{P}$$

$$W_s = \frac{nRT \ln\left(\frac{30}{3}\right)}{0,7}, \quad n = 50 \text{ mol/s}, \quad R = 8,314 \frac{J}{mol \cdot K}$$

$$T = 300 K$$

$$W_s = 410 \text{ kJ/s}$$

1b) $$W_s(T) = \frac{nRT \ln\left(\frac{P_1}{P_0}\right)}{\mu}, \quad T = 400$$

$$W_s = 547 \text{ kJ/s}$$

1c)

$P_0 = 3$ bar $\quad P_1 = 10$ bar $\quad P_f = 30$ bar

$T_0 = 400 K \quad T_3 = 400 K$

Adiabatisk prosess $\rightarrow Q = 0 \rightarrow W_s^{rev} = H_2 - H_1$

Første kompresjon

$H = nC_pT$

$W_s^{rev} = nC_p(T_2 - T_1)$, antar C_p konstant

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}, \quad \gamma = \frac{C_p}{C_v} \rightarrow \frac{\gamma-1}{\gamma} = \frac{R}{C_p}$$

$$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{R}{C_p}}, \quad T_1 = 400K, \; P_2 = 10 \text{ bar}, \; P_1 = 3 \text{ bar}$$

$$C_p = 30 \frac{J}{kmol}$$

$$T_2 = 558 K$$

$$W_s^{rev} = 237 \text{ kJ/s} \rightarrow W_s = \frac{338}{\text{kJ/s}}, \quad \mu = 0,7$$

Forts. oppg 2c)

kompresjon 1 : 338 kW

kompresjon 2:

$$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{R}{C_p}}, \quad P_2 = 30\,bar,\ P_1 = 10\,bar,\ T_1 = 400\,K,\ C_p = 30$$

$$T_2 = 542\,K$$

$$W_s = \frac{W_s^m}{0,7} = \frac{n C_p (T_2 - T_1)}{0,7} = 304\,kW$$

$$W_s = W_s' + W_s^2 = (338 + 304)\,kW = 642\,kW$$

2d)

$$W_s = n C_p (T_4 - T_3), \quad T_3 = 400\,K,\ n = 50\,mol/s,\ C_p = 30\,\frac{J}{K \cdot mol}$$

$$\frac{W_s^*}{n C_p} + T_3 = T_4$$

$$W_s = 304\,kW$$

$$T_4 = 602\,K$$

2e) Reell temp etter kompresjon 1:

$$T_2 = \frac{W_s}{n C_p} + T_1 \rightarrow T_2 = 625\,K$$

$$Q = n C_p (T_3 - T_2) \rightarrow Q = -337\,kW$$

$$Q = U A \ln \Delta T_{lm}$$

$$\Delta T_{lm} = \frac{(625\,K - 400\,K) - (400\,K - 300\,K)}{\ln\left(\frac{625-400}{400-300}\right)}$$

$$A \approx 10$$

$$Q = n C_p (400\,K - 300\,K) = 337\,kW$$

$$n = 0,8\,kg/s$$