BGTD – 9. Hőtőkörfolyamatok és körfolyamatok

9.3.1. $\varepsilon \equiv COP = 4$ [1]

$|\dot{Q}_{el}| = 100$ [kW]

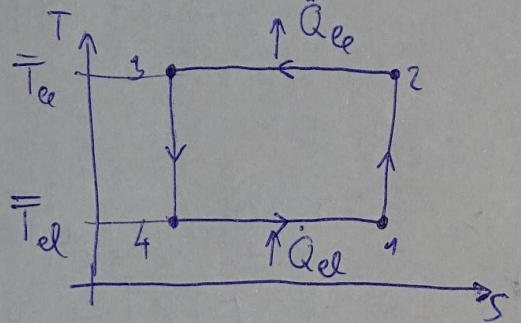
$$\varepsilon = \frac{|\dot{Q}_{el}|}{|\dot{W}|} \Rightarrow |\dot{W}| = \frac{|\dot{Q}_{el}|}{\varepsilon} = 25 \text{ [kW]}$$

$$|\dot{W}| = |\dot{Q}_{fe}| - |\dot{Q}_{el}| = \frac{|\dot{Q}_{el}|}{\varepsilon} = |\dot{W}|$$

$$|\dot{Q}_{fe}| = |\dot{Q}_{el}|\left(1 + \frac{1}{\varepsilon}\right) = 125 \text{ [kW]}$$

9.3.2. $|\dot{Q}_{el}| = 40$ [kW]

$\bar{T}_{fe} = 45$ [°C] $\qquad |\dot{Q}_{fe}| = 50$ [kW]



$$\varepsilon = \frac{|\dot{Q}_{el}|}{|\dot{W}|} = \frac{|\dot{Q}_{el}|}{|\dot{Q}_{fe}| - |\dot{Q}_{el}|} =$$

$$= \frac{\left|\int_4^3 T\,ds\right|}{\left|\int_2^3 T\,ds\right| - \left|\int_4^1 T\,ds\right|} = \frac{\bar{T}_{el}(s_1 - s_4)}{\bar{T}_{fe}(s_2 - s_3) - \bar{T}_{el}(s_1 - s_4)} =$$

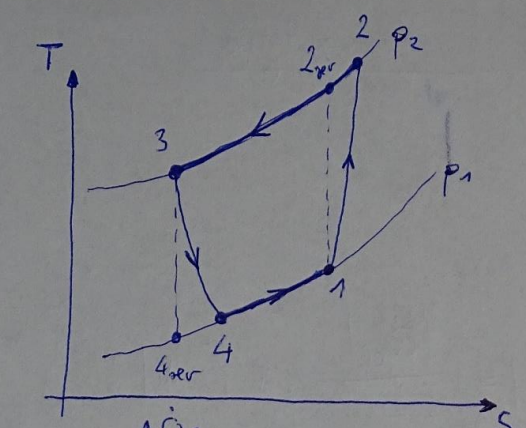
$$= \frac{\bar{T}_{el}}{\bar{T}_{fe} - \bar{T}_{el}}$$

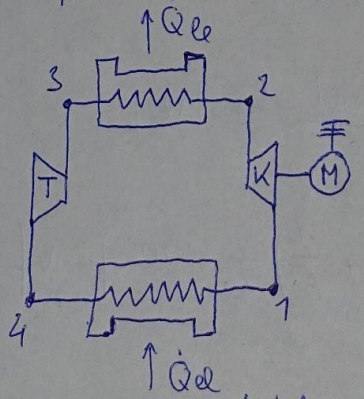
$s_1 = s_2$, $s_3 = s_4$

$$\varepsilon = \frac{|\dot{Q}_{el}|}{|\dot{Q}_{fe}| - |\dot{Q}_{el}|} = 4 \text{ [1]}$$

$$\varepsilon = \frac{\bar{T}_{el}}{\bar{T}_{fe} - \bar{T}_{el}} \Rightarrow \bar{T}_{el} = \bar{T}_{fe}\,\frac{\varepsilon}{1+\varepsilon} = 254{,}4\text{[K]} = -18{,}6\text{ [°C]}$$

9.4.1.





$$\Pi = \frac{p_2}{p_1} = 4\,[1]$$

$T_3 = 35\,[°C]$

$\eta_K = 82\,[\%]$ $\quad \eta_T = 92\,[\%]$

$|\dot{Q}_{el}| = 25\,[kW]$ $\quad \dot{m} = 10\,\left[\frac{kg}{s}\right]$

$\varkappa = 1{,}33\,[1]$ $\quad R = 189\,\left[\frac{J}{kg\,K}\right]$

$3 \to 4_{rev}$: adiabatikus + reverzibilis expanzió: $n = \varkappa$

$$\frac{T_{4,rev}}{T_3} = \left(\frac{p_{4,rev}}{p_3}\right)^{\frac{\varkappa-1}{\varkappa}} = \left(\frac{1}{\Pi}\right)^{\frac{\varkappa-1}{\varkappa}} \Rightarrow T_{4,rev} = T_3\left(\frac{1}{\Pi}\right)^{\frac{\varkappa-1}{\varkappa}} =$$

$p_{4,rev} = p_4 = p_1$

$p_3 = p_2$

$$= 218{,}357\,[K]$$

$$\eta_T = \frac{h_3 - h_4}{h_3 - h_{4,rev}} = \frac{c_p\,(T_3 - T_4)}{c_p\,(T_3 - T_{4,rev})} \Rightarrow T_4 = T_3 - \eta_T\,(T_3 - T_{4,rev}) =$$

$$= 225{,}53\,[K] = -47{,}47\,[°C]$$

$$|\dot{Q}_{el}| = |\dot{Q}_{41}| = \dot{m}\,\underbrace{c_p}_{\frac{\varkappa R}{\varkappa-1}}\,(T_1 - T_4) \Rightarrow T_1 = \frac{(\varkappa-1)\,|\dot{Q}_{el}|}{\dot{m}\,\varkappa R} + T_4 =$$

$$= 228{,}811\,[K] = -44{,}19\,[°C]$$

$1 \to 2_{rev}$: adiabatikus + reverzibilis kompresszió: $n = \varkappa$

$$\frac{T_{2,rev}}{T_1} = \left(\frac{p_{2,rev}}{p_1}\right)^{\frac{\varkappa-1}{\varkappa}} = \Pi^{\frac{\varkappa-1}{\varkappa}} \Rightarrow T_{2,rev} = T_1\,\Pi^{\frac{\varkappa-1}{\varkappa}} = 322{,}74\,[K] =$$

$p_{2,rev} = p_2$

$$= 49{,}74\,[°C]$$

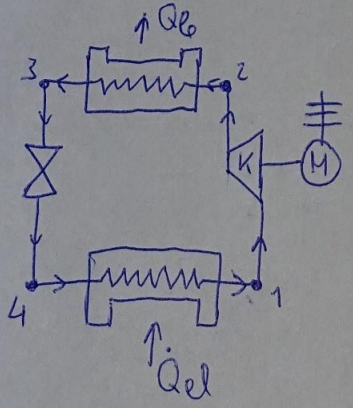
$$\eta_K = \frac{h_{2rev} - h_1}{h_2 - h_1} = \frac{c_p (T_{2rev} - T_1)}{c_p (T_2 - T_1)} \Rightarrow T_2 = T_1 + \frac{1}{\eta_K} (T_{2rev} - T_1) =$$

$$= 343,36\ [K] = 70,36\ [°C]$$

$$|\dot{Q}_{fe}| = |\dot{Q}_{23}| = \underbrace{c_p}_{\frac{\varkappa R}{\varkappa - 1}} \dot{m} (T_2 - T_3) = 269,35\ [kW]$$

$$\varepsilon \equiv COP = \frac{|\dot{Q}_{el}|}{|\dot{W}|} = \frac{|\dot{Q}_{el}|}{|\dot{Q}_{fe}| - |\dot{Q}_{el}|} = 0,1023\ [1]$$

9.5.1.

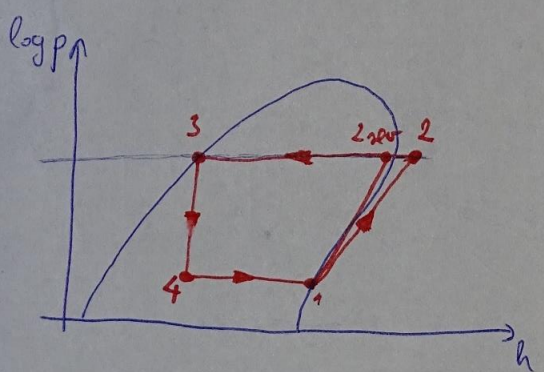


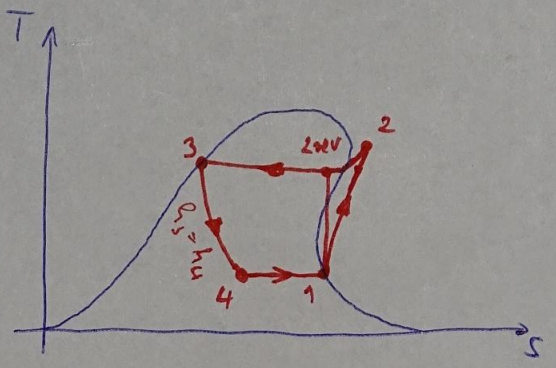
$T_{pár} = -20\ [°C]$

$T_{kon} = 40\ [°C]$

$\eta_K = 80\ [\%]$

$|\dot{Q}_{el}| = 150\ [kW]$





$s_{2rev} = s_1 = s''(T_{sat} = T_{pár}) < s''(T_{sat} = T_{kon}) \Rightarrow$ reverzibilis expanzió a kétfázisú mezőben ér véget

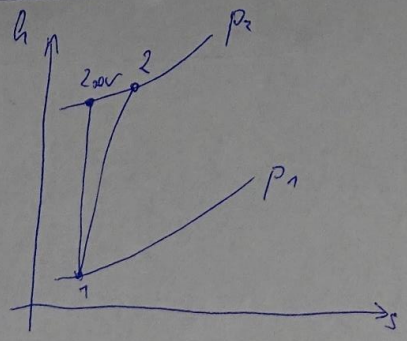
$$x_{2rev} = \frac{s_{2rev} - s'(T_{sat} = T_{kon})}{s''(T_{sat} = T_{kon}) - s'(T_{sat} = T_{kon})} = 0,9801\ [1]$$

$$h_{2rev} = (1 - x_{2rev})\, h'(T_{sat} = T_{kon}) + x_{2rev}\, h''(T_{sat} = T_{kon}) = 601,6008\ \left[\frac{kJ}{kg}\right]$$

$$\eta_k = \frac{h_{2rev} - h_1}{h_2 - h_1} \Rightarrow h_2 = h_1 + \frac{1}{\eta_k}(h_{2rev} - h_1) =$$

$$= 620{,}0985 \left[\frac{kJ}{kg}\right]$$

$h_1 = h''(T_{sat} = T_{pár})$



$h_4 = h_3 = h'(T_{sat} = T_{kon})$

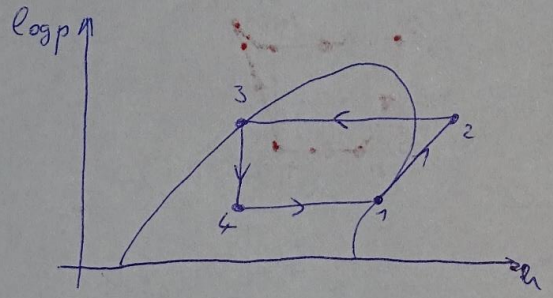
$$|\dot{Q}_{el}| = |\dot{Q}_{41}| = \dot{m}(h_1 - h_4) \Rightarrow \dot{m} = \frac{|\dot{Q}_{el}|}{h_1 - h_4} = 0{,}6484 \left[\frac{kg}{s}\right]$$

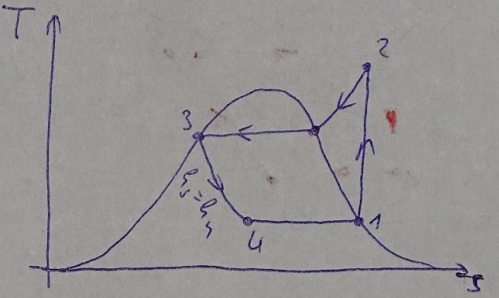
$$\varepsilon = \frac{|q_{el}|}{|w_k|} = \frac{h_1 - h_4}{h_2 - h_1} = 2{,}5012 \ [1]$$

$$|\dot{Q}_{el}| = \dot{m}|q_{el}| = \dot{m}(h_2 - h_3) = 209{,}97 \ [kW]$$

$$|\dot{W}_k| = \dot{m}|w_k| = \dot{m}(h_2 - h_1) = 59{,}97 \ [kW]$$

9.5.2. $T_{kon} = 20 \ [°C]$ $T_{pár} = -10 \ [°C]$ $\dot{m} = 1\left[\frac{t}{h}\right] = 0{,}2778 \left[\frac{kg}{s}\right]$





$s_2 = s_1 = s''(T_{sat} = T_{pár}) \Rightarrow$

$$\begin{cases} T_2 = T(p_{sat}(T = T_{kon}), s_2) = 64{,}2 [°C] \\ h_2 = h(p_{sat}(T = T_{kon}), s_2) = 1743{,}00 \left[\frac{kJ}{kg}\right] \end{cases}$$

gőztáblázatból v. diagramból

$$\varepsilon = \frac{|q_{el}|}{|w_k|} = \frac{h_1 - h_4}{h_2 - h_1} = 7{,}7596 \ [1]$$

$h_1 = h''(T_{sat} = T_{pár})$

$h_4 = h_3 = h'(T_{sat} = T_{kon})$

$$|\dot{W}_k| = \dot{m}|w_k| = \dot{m}(h_2 - h_1) = 41{,}42 \ [kW]$$