Politropska ekspanzija ($n = 1.15$), $p_1 = 7\ bar$, $T_1 = 693\ K$, $p_2 = 1\ bar$, dobivena snaga $P = 70\ kW$. $\left(R = 287\ J/kgK,\ c_v = 718\ J/kgK,\ c_p = 1005\ J/kgK\right)$

T_2, $\dot{m}[kg/h]$, $\dot{V}_1[m^3/h]$, $\dot{V}_2[m^3/h]$, Δs, $\Delta u = ?$

Vrijedi: $\frac{T_1}{T_2} = \left(\frac{p_1}{p_2}\right)^{\frac{n-1}{n}}$, $W = \frac{m \cdot R \cdot \Delta T}{1-n} = \frac{m \cdot R \cdot (T_1 - T_2)}{n-1}$, $P = \dot{m} \cdot w$, $\Delta U = m \cdot c_v \cdot \Delta T$,

$\Delta S = m \cdot c_n \cdot \ln\left(\frac{T_2}{T_1}\right)$ $\left[c_n = c_v \frac{n-\kappa}{n-1},\quad \kappa = \frac{c_p}{c_v}\right]$

$$\frac{T_1}{T_2} = \left(\frac{p_1}{p_2}\right)^{\frac{n-1}{n}} \Rightarrow T_2 = T_1 \cdot \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} = 693 \cdot \left(\frac{1}{7}\right)^{\frac{0.15}{1.15}} \qquad \boxed{T_2 = 537.6\ K}$$

$$W = \frac{m \cdot R \cdot (T_1 - T_2)}{n-1} \Rightarrow w = \frac{R \cdot (T_1 - T_2)}{n-1} = \frac{287 \cdot (693 - 537.6)}{1.15 - 1} = 297.332\ kJ/kg$$

$$P = \dot{m} \cdot w \Rightarrow \dot{m} = \frac{P}{w} = \frac{70}{297.332} = 0.2354\ kg/s = 3600 \cdot 0.2354 \qquad \boxed{\dot{m} = 847.54\ kg/h}$$

$$p_1 \cdot V_1 = m \cdot R \cdot T_1 \Rightarrow p_1 \cdot v_1 = R \cdot T_1 \Rightarrow v_1 = \frac{R \cdot T_1}{p_1} = 0.2841\ m^3/kg$$

$$\dot{V}_1 = v_1 \cdot \dot{m} = 0.2841 \cdot 847.54 \qquad \boxed{\dot{V}_1 = 240.82\ m^3/h}$$

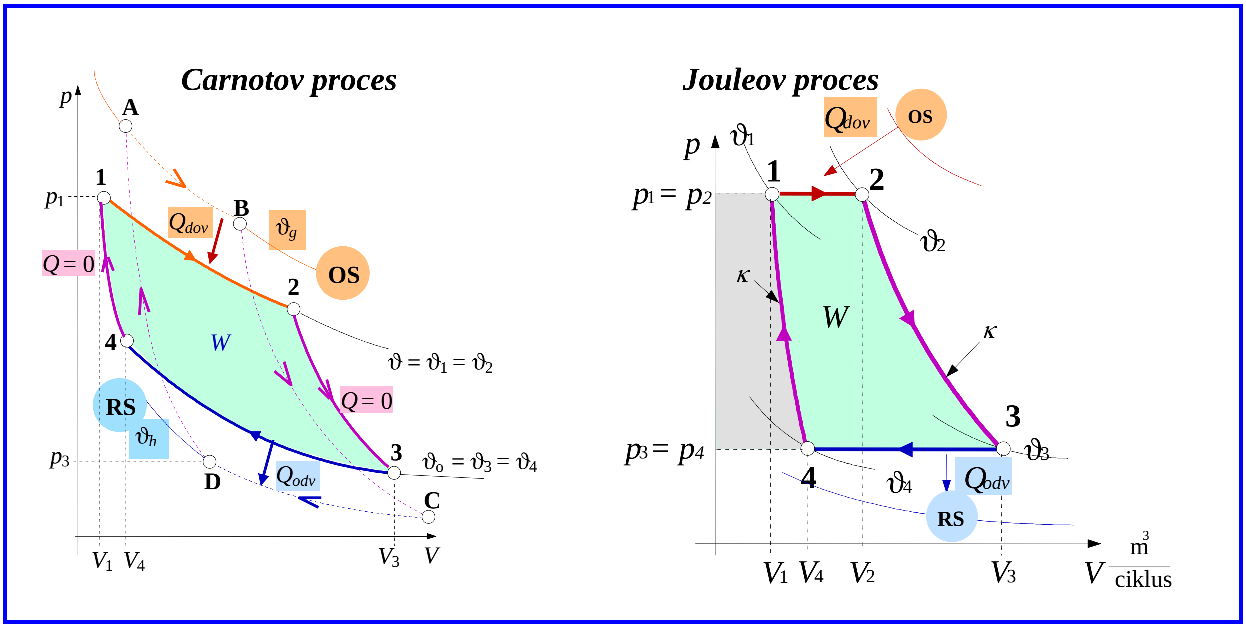
$$v_2 = \frac{R \cdot T_2}{p_2} = 1.5429\ m^3/kg \qquad \dot{V}_2 = v_2 \cdot \dot{m} = 1.5429 \cdot 847.54 \qquad \boxed{\dot{V}_2 = 1307.68\ m^3/h}$$

$$\Delta U = m \cdot c_v \cdot \Delta T \Rightarrow \Delta u = c_v \cdot \Delta T = 718 \cdot (537.6 - 693) \qquad \boxed{\Delta u = -111.58\ kJ/kg}$$

$$\kappa = \frac{c_p}{c_v} \approx 1.4 \Rightarrow c_n = c_v \frac{n-\kappa}{n-1} = 718 \frac{1.15 - 1.4}{1.15 - 1} = -1196.667$$

$$\Delta S = m \cdot c_n \cdot \ln\left(\frac{T_2}{T_1}\right) \Rightarrow \Delta s = c_n \cdot \ln\left(\frac{T_2}{T_1}\right) = -1196.667 \cdot \ln\left(\frac{537.6}{693}\right) \qquad \boxed{\Delta s = 303.9\ J/kgK}$$

Traži se η_{JKP} (uz dobiven rad $W = 310\ \ kJ$), najviša i najniža temperatura kao kod c.k.p. sa $\eta_{CKP} = 0.77$ i $T_{ODV} = 340\ \ K$. ($c_v = 717\ \ J/kgK$ i $c_p = 1005\ \ J/kgK$)



Za sve kružne procese vrijedi $W = Q_{dov} - |Q_{odv}|$, $\Delta U = 0$ i $\eta = \dfrac{dobijeno}{ulozeno} = \dfrac{W}{Q_{dov}}$

Kod Carnota vrijedi $\eta_{CKP} = 1 - \dfrac{T_{odv}}{T_{dov}} = 1 - \dfrac{T_4}{T_1}$, a kod Joulea:

$$\eta_{JKP} = \frac{w}{q_{dov}} = \frac{q_{dov} - |q_{odv}|}{q_{dov}} = 1 - \frac{|q_{odv}|}{q_{dov}} = 1 - \frac{|c_p \cdot (T_4 - T_3)|}{c_p \cdot (T_2 - T_1)} = 1 - \frac{T_3 - T_4}{T_2 - T_1}$$

Za j.k.p. vrijedi i relacija mosta $T_1 \cdot T_3 = T_2 \cdot T_4$ $\left[zbog\ \ \dfrac{T_2}{T_3} = \left(\dfrac{p_1}{p_2}\right)^{\frac{\kappa-1}{\kappa}} \ \ i \ \ \dfrac{T_1}{T_4} = \left(\dfrac{p_1}{p_2}\right)^{\frac{\kappa-1}{\kappa}} \right]$

Onda je i $\eta_{JKP} = 1 - \dfrac{T_3 - T_4}{T_2 - T_1} = 1 - \dfrac{T_4 \cdot \left(\dfrac{T_3}{T_4} - 1\right)}{T_1 \cdot \left(\dfrac{T_2}{T_1} - 1\right)} \quad \Rightarrow \quad \eta_{JKP} = 1 - \dfrac{T_4}{T_1}$

$$\eta_{CKP} = 1 - \frac{T_{odv}}{T_{dov}} \quad \Rightarrow \quad T_{dov} = \frac{T_{odv}}{1 - \eta_{CKP}} = \frac{340}{0.23} = 1478.26\ \ K$$

za Joulea:

$\Rightarrow T_{najvisa} = T_2 = 1478.28\ \ K$

$T_{najniza} = T_4 = 340\ \ K$

dobiveni rad:

$$W = Q_{dov} - |Q_{odv}| \quad \Rightarrow \quad 310000 = c_p \cdot (T_2 - T_1) - |c_p \cdot (T_4 - T_3)| \quad \Rightarrow \quad \frac{310000}{1005} = (T_2 - T_1) - (T_3 - T_4)$$

vrijedi i: $T_1 \cdot T_3 = T_2 \cdot T_4 \quad \Rightarrow \quad T_3 = \dfrac{T_2 \cdot T_4}{T_1} = \dfrac{502608.4}{T_1}$ i to se ubaci dolje:

$$T_1 + T_3 + 308.46 - T_2 - T_4 = 0 \quad \Rightarrow \quad T_1^2 - 1509.82 \cdot T_1 + 502608.4 = 0$$

dva rješenja:

$\Rightarrow T_1 = 1014.30\ \ K$

$T_1 = 495.52\ \ K$

Od 2 mogućnosti uzmemo veću $T_1 = 1014.30\ \ K$ jer tako dovodimo manje topline za isti dobiveni rad $\left(Q_{dov} = c_p \cdot (T_2 - T_1)\right) \Rightarrow T_3 = \dfrac{T_2 \cdot T_4}{T_1} = 495.52\ \ K$ (manja od T_1 kao na $p \cdot V$ dijagramu). Korisnost za Jouleov k.p.: $\eta_{JKP} = 1 - \dfrac{T_4}{T_1} = 1 - \dfrac{340}{1014.3}$

$$\boxed{\eta_{JKP} = 0.665}$$

Godina	W [GWh]	
2000.	9700	W(0)
2001.	10500	W(1)
2002.	11100	W(2)
2003.	11800	W(3)
2004.	13000	W(4)

Naći koeficijente a i b jednadžbe za log. pravac i očekivanu proizvodnju [GWh] u 2007. godini.

logaritamski pravac:

$$\log W(t) = a \cdot t + b$$

razdoblje je od 2000. do 2004. $\Rightarrow\ T = 5\ \ godina$

koeficijenti a i b se računaju iz sistema jednadžbi:

$$T \cdot b + a \cdot \sum_{0}^{T-1} t - \sum_{0}^{T-1} \log W(t) = 0$$

$$b \cdot \sum_{0}^{T-1} t + a \cdot \sum_{0}^{T-1} t^2 - \sum_{0}^{T-1} \left[t \cdot \log W(t)\right] = 0$$

$$5 \cdot b + a \cdot \sum_{0}^{4} t - \sum_{0}^{4} \log W(t) = 0$$

$$b \cdot \sum_{0}^{4} t + a \cdot \sum_{0}^{4} t^2 - \sum_{0}^{4} \left[t \cdot \log W(t)\right] = 0$$

$$5 \cdot b + a \cdot (0 + \ldots + 4) - \left[\log W(0) + \ldots + \log W(4)\right] = 0$$

$$b \cdot (0 + \ldots + 4) + a \cdot \left(0^2 + \ldots + 4^2\right) - \left[0 \cdot \log W(0) + \ldots + 4 \cdot \log W(4)\right] = 0$$

$$5 \cdot b + 10 \cdot a - 20.2391 = 0 \qquad \Rightarrow \qquad 5 \cdot b = 20.2391 - 10 \cdot a$$

$$10 \cdot b + 30 \cdot a - 40.7833 = 0$$

$$\downarrow$$

$$5 \cdot b = 20.2391 - 10 \cdot 0.03051$$

$$\boxed{b = 3.9868}$$

$$2 \cdot (20.2391 - 10 \cdot a) + 30 \cdot a - 40.7833 = 0$$

$$10 \cdot a = 0.3051$$

$$\boxed{a = 0.03051}$$

gotova jednadžba logaritamskog pravca:

$$\log W(t) = 0.03051 \cdot t + 3.9868$$

Ako je za 2000. $t = 0$ onda je za 2007. $t = 7$, a očekivana potrošnja:

$$\log W(7) = 0.03051 \cdot 7 + 3.9868$$

$$W(7) = 10^{4.20037} = 15852.4403$$

$$\boxed{\text{u 2007. godini } W = 15862\ \ GWh}$$