

2.

$$m_1 = 850 \text{ kg}$$

$$c_1 = 80 \text{ km/h} = 22,22 \text{ m/s}$$

$$c_2 = \frac{c_1}{2} = 11,11 \text{ m/s}$$

$$q_v = 2260 \text{ kJ/kg}$$

$$\cancel{Q_{12}} + \cancel{U_1} + \cancel{E_{p1}} + \cancel{E_{k1}} = \cancel{U_{12}} + \cancel{U_2} + \cancel{E_{p2}} + \cancel{E_{k2}}$$

$$Q_{12} = \Delta E_k = E_{k2} - E_{k1}$$

$$Q_{12} = \frac{m}{2} (c_2^2 - c_1^2)$$

$$a) c_2 = 0$$

$$Q_{12} = -\frac{m}{2} c_1^2 = -209,83 \text{ kJ}$$

$$m_v = \frac{209,83}{2260} = 0,093 \text{ kg}$$

$$b) c_2 = 11,11 \text{ m/s}$$

$$Q_{12} = \frac{m}{2} (c_2^2 - c_1^2)$$

$$Q_{12} = -154,38 \text{ kJ}$$

$$m_v = 0,07 \text{ kg}$$

5.

$$m = 0.9 \text{ kg}$$

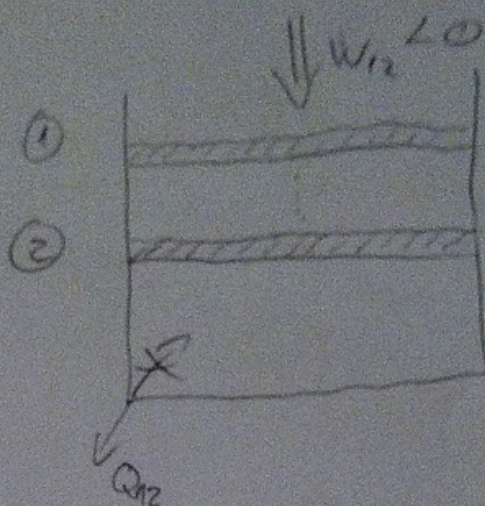
$$V_1 = 0.396 \text{ m}^3$$

$$V_2 = 0.255 \text{ m}^3$$

$$p = 95,76 \text{ kPa}$$

$$\Delta U = -8135 \text{ J}$$

$$Q_{12} = ?$$



$$Q_{12} + U_1 + \cancel{E_{p1}} + \cancel{E_{k1}} = W_{12} + U_2 + \cancel{E_{p2}} + \cancel{E_{k2}}$$

$$Q_{12} = W_{12} + \underbrace{U_2 - U_1}_{\Delta U}$$

$$W_{12} = p(V_2 - V_1) = 95760(0,255 - 0,396) = -13,502 \text{ kJ}$$

$$Q_{12} = W_{12} + \Delta U = -13,502 - 8,135 = -21,637 \text{ kJ}$$

Toplina se odvodi iz sistema.

10.

$$P_1 = 103 \text{ kPa}$$

$$P_2 = 680 \text{ kPa}$$

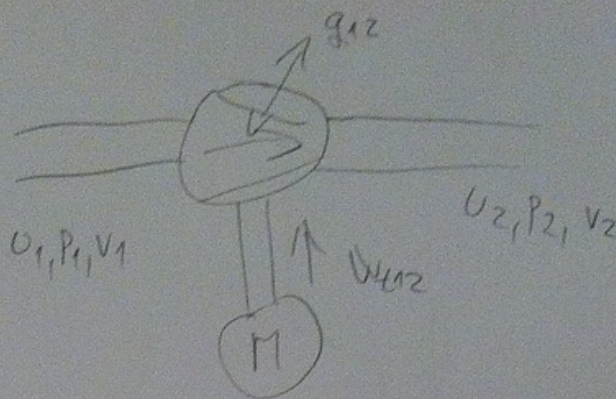
$$v_1 = 0,124 \text{ m}^3/\text{kg}$$

$$v_2 = 0,0312 \text{ m}^3/\text{kg}$$

$$\Delta U = 93,25 \text{ kJ/kg}$$

$$W_{t12} = -164 \text{ kJ/kg}$$

$$g_{12} = ?$$



$$g_{12} + U_2 + P_2 v_2 + \frac{1}{2} c_2^2 + g_{z2} = W_{t12} + U_1 + P_1 v_1 + \frac{1}{2} c_1^2 + g_{z1}$$

$$g_{12} = W_{t12} + U_2 - U_1 + P_2 v_2 - P_1 v_1$$

$$g_{12} = -164 + 93,25 + 680 \cdot 0,0312 - 103 \cdot 0,124$$

$$g_{12} = -62,306 \text{ kJ/kg}$$

12.

$$\dot{m} = 5 \text{ t/h} = 1,39 \text{ kg/s}$$

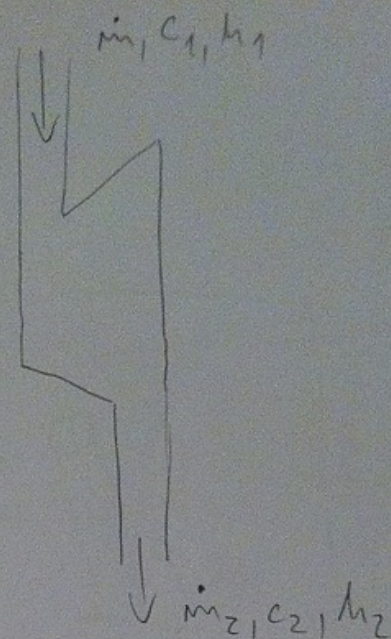
$$P_{t12} = 500 \text{ kW}$$

$$\Delta h = h_2 - h_1 = -490 \text{ kg/kg}$$

$$c_1 = 60 \text{ m/s}$$

$$c_2 = 360 \text{ m/s}$$

$$q_{12} = ?$$



$$\dot{m}_1 = \dot{m}_2 = \dot{m}$$

$$q_{12} + \underbrace{(u_1 + p_1 v_1)}_{h_1} + \frac{1}{2} c_1^2 + \cancel{g z_1} = \cancel{u_{t12}} + \underbrace{(u_2 + p_2 v_2)}_{h_2} + \frac{1}{2} c_2^2 + \cancel{g z_2}$$

$$q_{12} = \cancel{u_{t12}} + h_2 - h_1 + \frac{1}{2} (c_2^2 - c_1^2) / \dot{m} \left[\frac{\text{kg}}{\text{s}} \right]$$

$$\dot{Q}_{12} = 500 \cdot 10^3 + 1,39 \cdot (-490 \cdot 10^3) + \frac{1}{2} \cdot 1,39 (360^2 - 60^2)$$

$$\dot{Q}_{12} = -93,5 \frac{\text{kJ}}{\text{s}}$$

15.

$$D_2 = 5 \text{ cm}$$

$$z_2 - z_1 = 1.5 \text{ m}$$

$$T_1 = 10^\circ\text{C} + 273,15 = 283,15 \text{ K}$$

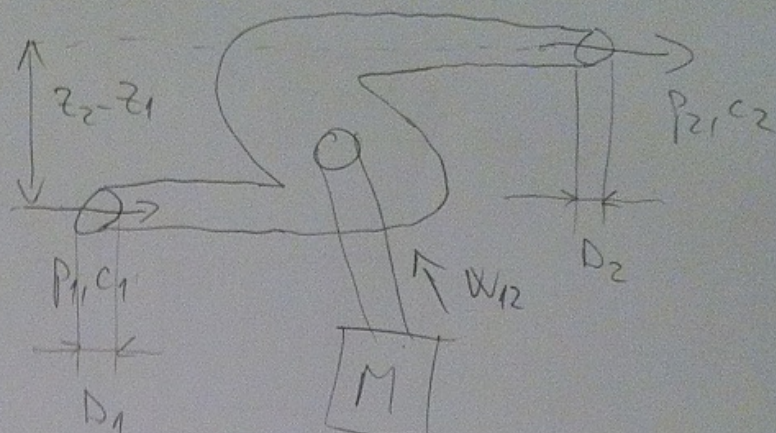
$$p_1 = 96,3 \text{ kPa}$$

$$D_1 = 4,5 \text{ cm}$$

$$p_2 = 0,3111 \text{ Pa}$$

$$Q = 0,0126 \text{ m}^3/\text{s}$$

$$\rho = 1000 \text{ kg/m}^3$$



$$g_{12} + \underbrace{h_1 + p_1 v_1}_{l_{h1}} + \frac{1}{2} c_1^2 + g z_1 = W_{t12} + \underbrace{h_2 + p_2 v_2}_{l_{h2}} + \frac{1}{2} c_2^2 + g z_2$$

$$h = u + p v / d$$

$$dh = \underbrace{du + p dv}_{dg} + v dp$$

$$dg - dh = -v dp / s^2$$

$$g_{12} - (h_2 - h_1) = - \int_1^2 v dp$$

$$W_{t12} = - \int_1^2 v dp - \frac{1}{2} (c_2^2 - c_1^2) - g(z_2 - z_1)$$

$$-g(z_2 - z_1) = -14,45 \text{ J/kg}$$

$$- \int_1^2 v dp = -v(p_2 - p_1) = -213,5 \text{ J/kg}$$

$$v \left[\frac{\text{m}^3}{\text{kg}} \right] = \frac{1}{\rho} = 0,001 \text{ m}^3/\text{kg}$$

$$- \frac{1}{2} (c_2^2 - c_1^2) = -16,522 \text{ J/kg}$$

$$W_{t12} = -213,5 - 16,522 - 14,45$$

$$P_{II} = +244,46 \text{ W} \quad \dot{m} = \rho \cdot Q$$

$$P_{II} = 316 \text{ W}$$

$$W_{t12} = -244,46 \text{ J/kg}$$

38.

$$T_1 = T_2 = 440 \text{ K}$$

$$T_3 = T_4 = 300 \text{ K}$$

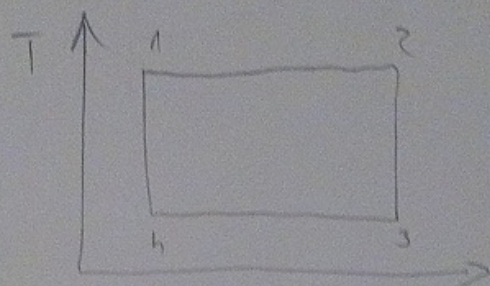
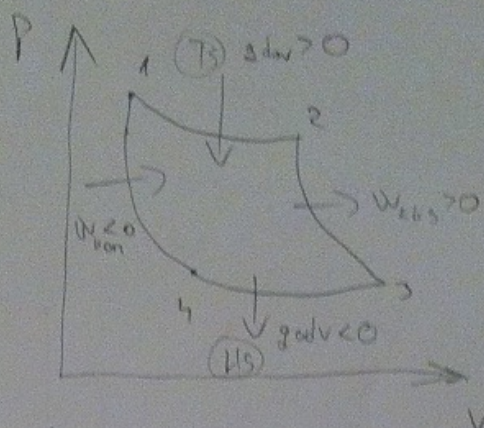
$$P_1 = 6,3 \text{ MPa}$$

$$P_3 = 0,1 \text{ MPa}$$

$$m = 5 \text{ kg}$$

$$R = 287 \text{ J/kgK}$$

$$\kappa = 1,4$$



$$\frac{P_2}{P_3} = \left(\frac{T_2}{T_3} \right)^{\frac{\kappa}{\kappa-1}} = \left(\frac{440}{300} \right)^{\frac{1,4}{0,4}}$$

$$P_2 = 2,357 \text{ MPa}$$

$$\frac{P_4}{P_1} = \left(\frac{T_4}{T_1} \right)^{\frac{\kappa}{\kappa-1}} \quad P_4 = 0,233 \text{ MPa}$$

$$PV = mRT \Rightarrow V = \frac{mRT}{P}, \quad V_1 = \frac{mRT}{P_1} \quad \dots \quad V_4 = \frac{mRT_4}{P_4}$$

$$V_1 = 0,154 \text{ m}^3, \quad V_2 = 0,451 \text{ m}^3, \quad V_3 = 4,305 \text{ m}^3, \quad V_4 = 1,463 \text{ m}^3$$

$$q_{\text{dov}} = RT_1 \ln \frac{V_2}{V_1} = RT_1 \ln \frac{P_1}{P_2} = 287 \cdot 440 \ln \frac{6,3}{2,357} = 1,141 \text{ MJ/kg}$$

$$PV = RT$$

$$PV = \text{const.} \Rightarrow T = \text{const.}$$

$$\frac{P_1}{P_2} = \frac{V_2}{V_1}$$

$$q_{\text{odv}} = RT_3 \ln \frac{V_1}{V_3} = RT_3 \ln \frac{P_3}{P_4}$$

$$= -0,463 \text{ MJ/kg}$$

$$W = q_{\text{dov}} + q_{\text{odv}} = 1,141 - 0,463 = 0,678 \text{ MJ}$$

$$\eta_{\text{Ct}} = \frac{W}{q_{\text{dov}}} = \frac{0,678}{1,141} = 0,594$$

$$\eta_{\text{Ct}} = 1 - \frac{T_{\text{odv}}}{T_{\text{dov}}} = 1 - \frac{300}{440} = 0,594$$

39.

$$P_1 = P_2 = 1,2 \text{ MPa}$$

$$P_3 = P_4 = 0,1 \text{ MPa}$$

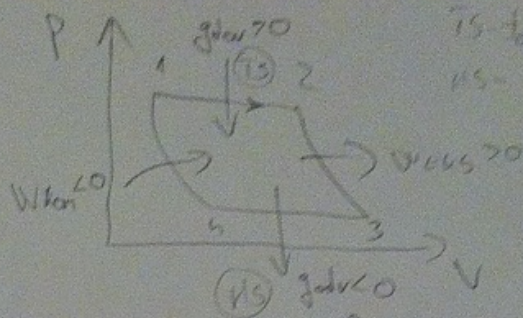
$$T_2 = 1400 \text{ K}$$

$$T_4 = 300 \text{ K}$$

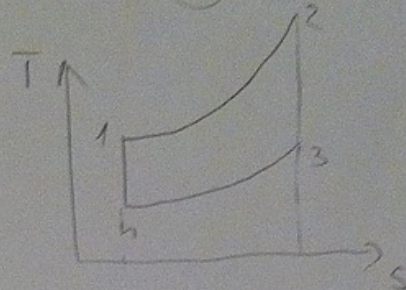
$$m = 10 \text{ kg}$$

$$R = 287 \text{ J/kgK}$$

$$k = 1,4$$



TS - isobaric expansion
 VS - isentropic expansion



$$\frac{T_2}{T_3} = \left(\frac{P_2}{P_3} \right)^{\frac{k-1}{k}} = \left(\frac{1,2}{0,1} \right)^{\frac{0,4}{1,4}}$$

$$T_3 = 688,32 \text{ K}$$

$$\frac{T_1}{T_4} = \left(\frac{P_1}{P_4} \right)^{\frac{k-1}{k}} \Rightarrow T_1 = 610,18 \text{ K}$$

$$PV = mRT \quad V = \frac{mRT}{P}$$

$$V_1 = \frac{mRT_1}{P_1}$$

$$V_1 = 1,459 \text{ m}^3, V_2 = 3,368 \text{ m}^3, V_3 = 19,755 \text{ m}^3, V_4 = 8,61 \text{ m}^3$$

$$dq = c_p \cdot dT$$

$$Q_{\text{dov}} = m \cdot c_p (T_2 - T_1) = 10 \cdot 1004,5 \cdot (1400 - 610,18) = +4,934 \text{ MJ}$$

$$\frac{c_p}{c_v} = k \quad c_p = c_v + R$$

$$c_p = \frac{R}{1 - \frac{1}{k}} = 1004,5 \text{ J/kgK}$$

$$Q_{\text{abv}} = m \cdot c_p (T_4 - T_3) = 10 \cdot 1004,5 (300 - 688,32) = -3,901 \text{ MJ}$$

$$dq = du + p dv = dh - v dp = 0$$

$$dh = v dp$$

$$h = u + p v$$

$$dh = du + p dv + v dp$$

$$w_{12} = - \int_1^2 v dp = - \int_1^2 dh = c_p (T_2 - T_1)$$

$$dh = c_p dT \quad w_{\text{dov}} = m \cdot c_p (T_2 - T_3) = +4,149 \text{ MJ}$$

$$W_{\text{ent}} = m \cdot c_p \cdot (T_h - T_c) = 10 \cdot 1004,5 \cdot (300 - 610,88) \\ = -3,116 \text{ MJ}$$

$$\eta_t = \frac{W}{Q_{\text{dov}}} = \frac{Q_{\text{dov}} + Q_{\text{odv}}}{Q_{\text{dov}}} = 0.508$$

$$\eta_t = 1 - \frac{T_h}{T_c} = 0.508$$

(TP) - toplika pumpe

LKP

$$\frac{|Q_{\text{dov}}|}{|W|} > 1$$

VL - hladilnik

$$\frac{|Q_{\text{odv}}|}{|W|} > 1$$

DIT

$$\eta_t < 1$$