Sistem içindeki 15kg hava 25°C'den 77°C'ye ısıtılmaktadır. Basınç süreç boyunca 300kPa sabit kalmaktadır. Çevreye 60 kj ısı geçişi olmaktadır. Elektrik enerjisini bulunuz (kWh)?

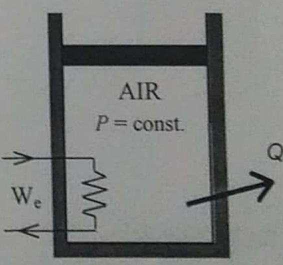
**4-65** A cylinder is initially filled with air at a specified state. Air is heated electrically at constant pressure, and some heat is lost in the process. The amount of electrical energy supplied is to be determined. √

***Assumptions*** **1** The cylinder is stationary and thus the kinetic and potential energy changes are zero. **2** Air is an ideal gas with variable specific heats. **3** The thermal energy stored in the cylinder itself and the resistance wires is negligible. **4** The compression or expansion process is quasi-equilibrium.

***Properties*** The initial and final enthalpies of air are (Table A-17)

$$h_1 = h_{@298\text{ K}} = 298.18 \text{ kJ/kg}$$

$$h_2 = h_{@350\text{ K}} = 350.49 \text{ kJ/kg}$$




***Analysis*** We take the contents of the cylinder as the system. This is a closed system since no mass enters or leaves. The energy balance for this closed system can be expressed as

$$\underbrace{E_{in} - E_{out}}_{\substack{\text{Net energy transfer}\\ \text{by heat, work, and mass}}} = \underbrace{\Delta E_{\text{system}}}_{\substack{\text{Change in internal, kinetic,}\\ \text{potential, etc. energies}}}$$

$$W_{\text{e,in}} - Q_{\text{out}} - W_{\text{b,out}} = \Delta U \longrightarrow W_{\text{e,in}} = m(h_2 - h_1) + Q_{\text{out}}$$

since $\Delta U + W_b = \Delta H$ during a constant pressure quasi-equilibrium process. Substituting,

$$W_{\text{e,in}} = (15 \text{ kg})(350.49 - 298.18)\text{kJ/kg} + (60 \text{ kJ}) = 845 \text{ kJ}$$

or, $$W_{e,in} = (845\text{kJ})\left(\frac{1 \text{ kWh}}{3600 \text{ kJ}}\right) = \mathbf{0.235 \text{ kWh}}$$

***Alternative solution*** The specific heat of air at the average temperature of $T_{\text{avg}} = (25+77)/2 = 51°\text{C} = 324$ K is, from Table A-2b, $c_{p,\text{avg}} = 1.0065$ kJ/kg.°C. Substituting,

$$W_{\text{e,in}} = mc_p(T_2 - T_1) + Q_{\text{out}} = (15 \text{ kg})(1.0065 \text{ kJ/kg.°C})(77-25)\text{°C} + 60 \text{ kJ} = 845 \text{ kJ}$$

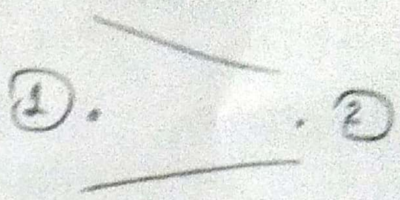
or, $$W_{\text{e,in}} = (845 \text{ kJ})\left(\frac{1 \text{ kWh}}{3600 \text{ kJ}}\right) = \mathbf{0.235 \text{ kWh}}$$

***Discussion*** Note that for small temperature differences, both approaches give the same result.

Hava kesit alanı çıkış kesit alanına oranı 2:1'dir.

$P_1 = 600\,kPa \quad T_1 = 500K \quad V_1 = 120\,m/s$

$V_2 = 380\,m/s \quad T_2 = ? \quad P_2 = ?$




$\dot{m}(h_1 + V_1^2/2) = \dot{m}(h_2 + V_2^2/2) \qquad \dot{Q} = \dot{W} = \Delta PE = 0$

$$h_2 = h_1 - \frac{V_2^2 - V_1^2}{2} = \frac{380^2 - 120^2}{2} = 438020\,j/kg = 438,02\,kj/kg$$

$h_2 = 438,02\,kj/kg$ A-17'den tersine okunur.

$T_2 = 436,5\,K$

$$\frac{1}{v_2} A_2 V_2 = \frac{1}{v_1} A_1 V_1 \Rightarrow \frac{1}{RT_2/P_2} A_2 V_2 = \frac{1}{RT_1/P_1} A_1 V_1$$

$$P_2 = \frac{A_1 T_2 V_1}{A_2 T_1 V_2} P_1 = \frac{2}{1} \cdot \frac{436,5 \cdot 120}{500 \cdot 380} \cdot 600 = 330,8\,kPa$$

Sistem başlangıç konumunda şekildeki gibidir, Pistonu hareket ettirmek için 400kPa basınca gerek vardır, Sistem hacmi iki kat olana kadar ısı geçişi olduğuna göre (sisteme verilen ısı miktarını ve yapılan işi bulunuz)

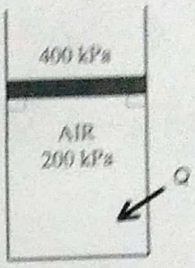
$P_1 = 200\,kPa$ $T_1 = 27°C$ $m = 3\,kg$.

**4-72** A cylinder equipped with a set of stops for the piston is initially filled with air at a specified state. Heat is transferred to the air until the volume doubled. The work done by the air and the amount of heat transfer are to be determined, and the process is to be shown on a *P-v* diagram.

***Assumptions*** **1** Air is an ideal gas with variable specific heats. **2** The kinetic and potential energy changes are negligible, $\Delta ke \cong \Delta pe \cong 0$. **3** The thermal energy stored in the cylinder itself is negligible. **4** The compression or expansion process is quasi-equilibrium.

***Properties*** The gas constant of air is $R = 0.287$ kPa.m³/kg.K (Table A-1).

***Analysis*** We take the air in the cylinder as the system. This is a closed system since no mass crosses the boundary of the system. The energy balance for this closed system can be expressed as




$$\underbrace{E_{in} - E_{out}}_{\substack{\text{Net energy transfer}\\ \text{by heat, work, and mass}}} = \underbrace{\Delta E_{system}}_{\substack{\text{Change in internal, kinetic,}\\ \text{potential, etc. energies}}}$$

$$Q_{in} - W_{b,out} = \Delta U = m(u_3 - u_1)$$

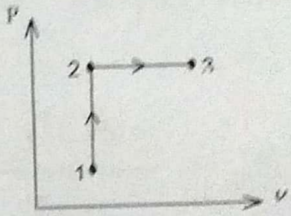
$$Q_{in} = m(u_3 - u_1) + W_{b,out}$$

The initial and the final volumes and the final temperature of air are

$$V_1 = \frac{mRT_1}{P_1} = \frac{(3\text{ kg})(0.287\text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(300\text{ K})}{200\text{ kPa}} = 1.29\text{ m}^3$$

$$V_3 = 2V_1 = 2\times 1.29 = 2.58\text{ m}^3$$

$$\frac{P_1V_1}{T_1} = \frac{P_3V_3}{T_3} \longrightarrow T_3 = \frac{P_3}{P_1}\frac{V_3}{V_1}T_1 = \frac{400\text{ kPa}}{200\text{ kPa}}\times 2\times(300\text{ K}) = 1200\text{ K}$$




No work is done during process 1-2 since $V_1 = V_2$. The pressure remains constant during process 2-3 and the work done during this process is

$$W_{b,out} = \int_1^2 P\,dV = P_2(V_3 - V_2) = (400\text{ kPa})(2.58 - 1.29)\text{m}^3 = \mathbf{516\ kJ}$$

The initial and final internal energies of air are (Table A-17)

$$u_1 = u_{@300\text{ K}} = 214.07\text{ kJ/kg}$$

$$u_3 = u_{@1200\text{ K}} = 933.33\text{ kJ/kg}$$

Then from the energy balance,

$$Q_{in} = (3\text{ kg})(933.33 - 214.07)\text{kJ/kg} + 516\text{ kJ} = \mathbf{2674\ kJ}$$

***Alternative solution*** The specific heat of air at the average temperature of $T_{avg} = (300 + 1200)/2 = 750$ K is, from Table A-2b, $c_{v,avg} = 0.800$ kJ/kg.K. Substituting,

$$Q_{in} = m(u_3 - u_1) + W_{b,out} \cong mc_v(T_3 - T_1) + W_{b,out}$$

$$Q_{in} = (3\text{ kg})(0.800\text{ kJ/kg.K})(1200 - 300)\text{ K} + 516\text{ kJ} = \mathbf{2676\ kJ}$$

Aşağıda şekilde verilen sistemde 3kg hava vardır. Sisteme ısı girişi olduğunda durdurunculara kadar genleşmekte, sonra basınç iki kat artana kadar ısı geçişi devam etmektedir. Verilen ısıyı bulunuz? İşi bulunuz?



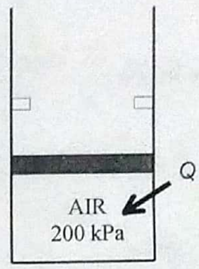
$P_1 = 200 kPa$. $T_1 = 27°C$

**4-73** [*Also solved by EES on enclosed CD*] A cylinder equipped with a set of stops on the top is initially filled with air at a specified state. Heat is transferred to the air until the piston hits the stops, and then the pressure doubles. The work done by the air and the amount of heat transfer are to be determined, and the process is to be shown on a *P-v* diagram.

***Assumptions*** **1** Air is an ideal gas with variable specific heats. **2** The kinetic and potential energy changes are negligible, $\Delta ke \cong \Delta pe \cong 0$. **3** There are no work interactions involved. **3** The thermal energy stored in the cylinder itself is negligible.

***Properties*** The gas constant of air is $R = 0.287$ kPa.m$^3$/kg.K (Table A-1).

***Analysis*** We take the air in the cylinder to be the system. This is a closed system since no mass crosses the boundary of the system. The energy balance for this closed system can be expressed as




$$\underbrace{E_{in} - E_{out}}_{\substack{\text{Net energy transfer} \\ \text{by heat, work, and mass}}} = \underbrace{\Delta E_{system}}_{\substack{\text{Change in internal, kinetic,} \\ \text{potential, etc. energies}}}$$

$$Q_{in} - W_{b,out} = \Delta U = m(u_3 - u_1)$$

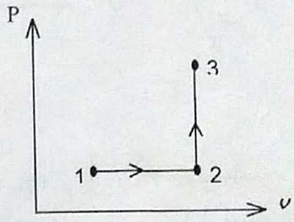
$$Q_{in} = m(u_3 - u_1) + W_{b,out}$$

The initial and the final volumes and the final temperature of air are determined from

$$V_1 = \frac{mRT_1}{P_1} = \frac{(3\text{ kg})(0.287\text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(300\text{ K})}{200\text{ kPa}} = 1.29\text{ m}^3$$

$$V_3 = 2V_1 = 2 \times 1.29 = 2.58\text{ m}^3$$

$$\frac{P_1V_1}{T_1} = \frac{P_3V_3}{T_3} \longrightarrow T_3 = \frac{P_3}{P_1}\frac{V_3}{V_1}T_1 = \frac{400\text{ kPa}}{200\text{ kPa}} \times 2 \times (300\text{ K}) = 1200\text{ K}$$




No work is done during process 2-3 since $V_2 = V_3$. The pressure remains constant during process 1-2 and the work done during this process is

$$W_b = \int_1^2 PdV = P_2(V_3 - V_2) = (200\text{ kPa})(2.58 - 1.29)\text{ m}^3\left(\frac{1\text{ kJ}}{1\text{ kPa}\cdot\text{m}^3}\right) = \mathbf{258\text{ kJ}}$$

The initial and final internal energies of air are (Table A-17)

$$u_1 = u_{@\,300\text{ K}} = 214.07\text{ kJ/kg}$$

$$u_2 = u_{@\,1200\text{ K}} = 933.33\text{ kJ/kg}$$

Substituting,

$$Q_{in} = (3\text{ kg})(933.33 - 214.07)\text{kJ/kg} + 258\text{ kJ} = \mathbf{2416\text{ kJ}}$$

***Alternative solution*** The specific heat of air at the average temperature of $T_{avg} = (300 + 1200)/2 = 750$ K is, from Table A-2b, $c_{v avg} = 0.800$ kJ/kg.K. Substituting

$$Q_{in} = m(u_3 - u_1) + W_{b,out} \cong mc_v(T_3 - T_1) + W_{b,out}$$
$$= (3\text{ kg})(0.800\text{ kJ/kg.K})(1200 - 300)\text{ K} + 258\text{ kJ} = \mathbf{2418\text{ kJ}}$$

Piston silindir içindeki azot gazı hacmi yarıya ininceye kadar sıkıştırılıyor. Hal değişimi $PV^{1,3} = sbt$ olacak şekilde politropiktir. $P_1 = 100\,kPa$ $T_1 = 27°C$ $m = 0.8\,kg$



**4-67** A cylinder initially contains nitrogen gas at a specified state. The gas is compressed polytropically until the volume is reduced by one-half. The work done and the heat transfer are to be determined.

***Assumptions*** **1** The cylinder is stationary and thus the kinetic and potential energy changes are zero. **2** The $N_2$ is an ideal gas with constant specific heats. **3** The thermal energy stored in the cylinder itself is negligible. **4** The compression or expansion process is quasi-equilibrium.

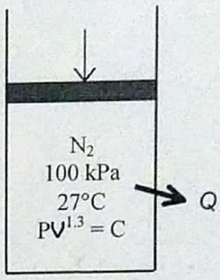
***Properties*** The gas constant of $N_2$ are $R = 0.2968$ kPa.m$^3$/kg.K (Table A-1). The $c_v$ value of $N_2$ at the average temperature (369+300)/2 = 335 K is 0.744 kJ/kg.K (Table A-2b).

***Analysis*** We take the contents of the cylinder as the system. This is a closed system since no mass crosses the system boundary. The energy balance for this closed system can be expressed as

$$\underbrace{E_{in} - E_{out}}_{\substack{\text{Net energy transfer}\\ \text{by heat, work, and mass}}} = \underbrace{\Delta E_{system}}_{\substack{\text{Change in internal, kinetic,}\\ \text{potential, etc. energies}}}$$

$$W_{b,in} - Q_{out} = \Delta U = m(u_2 - u_1)$$

$$W_{b,in} - Q_{out} = mc_v(T_2 - T_1)$$




The final pressure and temperature of nitrogen are

$$P_2V_2^{1.3} = P_1V_1^{1.3} \longrightarrow P_2 = \left(\frac{V_1}{V_2}\right)^{1.3} P_1 = 2^{1.3}(100 \text{ kPa}) = 246.2 \text{ kPa}$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \longrightarrow T_2 = \frac{P_2}{P_1}\frac{V_2}{V_1}T_1 = \frac{246.2 \text{ kPa}}{100 \text{ kPa}} \times 0.5 \times (300 \text{ K}) = 369.3 \text{ K}$$

Then the boundary work for this polytropic process can be determined from

$$W_{b,in} = -\int_1^2 P\,dV = -\frac{P_2V_2 - P_1V_1}{1-n} = -\frac{mR(T_2 - T_1)}{1-n}$$

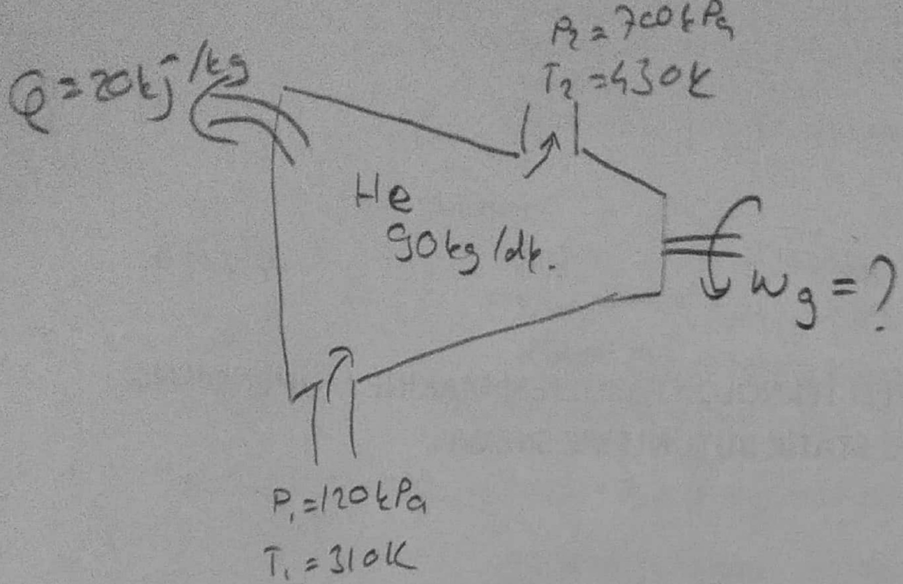
$$= -\frac{(0.8 \text{ kg})(0.2968 \text{ kJ/kg}\cdot\text{K})(369.3 - 300)\text{K}}{1-1.3} = \mathbf{54.8\ kJ}$$

Substituting into the energy balance gives

$$Q_{out} = W_{b,in} - mc_v(T_2 - T_1)$$

$$= 54.8 \text{ kJ} - (0.8 \text{ kg})(0.744 \text{ kJ/kg.K})(369.3 - 360)\text{K}$$

$$= \mathbf{13.6\ kJ}$$




$$W_{in} + \dot{m} h_1 = \dot{Q} + m h_2 \qquad (\Delta PE = \Delta KE = 0)$$

$$W_{in} - \dot{Q} = \dot{m}(h_2 - h_1) = \dot{m} c_p (T_2 - T_1)$$

$\dot{m} = \frac{90}{60} = 1,5 \text{ kg/s}$ $\qquad \dot{Q} = 20 \text{ kj/kg} \cdot 1,5 \text{ kg/s} = 30 \text{ kj/s} = 30 \text{ kW}$

$$W = Q + m c_p (T_2 - T_1) = 30 + 1,5 \cdot (5,1926 \text{ kj/kg·K})(430 - 310)\text{ K}$$

$$\boxed{W = 965 \text{ kW}}$$

Scanned by CamScanner

$P_1 = 300 kPa$

$T_1 = 200°C$    Hava

$V_1 = 30 m/s$ $\longrightarrow$

$A_1 = 80 cm^2$

$P_2 = 100 kPa$

$V_2 = 180 m/s$

$T_2 = ?$

$A_2 = ?$

$\dot{m} = ?$

$R = 0,287 \; kPa \, m^3/kg.K$ (Tablo - A-1)

$c_{p@450K} = 1,02 \; kj/kg.°C$ (Tablo - A-2)

$\dot{m}_{in} = \dot{m}_{out} = \dot{m}$

$$v_1 = \frac{RT_1}{P_1} = \frac{0,287 \, . \, 473}{300} = 0,4525 \; m^3/kg$$

$$\dot{m} = \frac{1}{v_1} A_1 V_1 = \frac{1}{0,4525 \, m^3/kg} \cdot (0,008 m^2).(30 m/s) = \underline{\underline{0,5304 \; kg/s}}$$

Enerji eşitliği:

$$\dot{m}(h_1 + V_1^2/2) = \dot{m}(h_2 + V_2^2/2) \qquad \boxed{\dot{Q} = \dot{W} = \Delta PE = 0}$$

$$0 = h_2 - h_1 + \frac{V_2^2 - V_1^2}{2} \qquad 0 = c_p(T_2 - T_1) + \frac{V_2^2 - V_1^2}{2}$$

$$0 = 1,02 \, (T_2 - 200) + \frac{(180)^2 - 30^2}{2} \cdot \frac{1 kj/kg}{1000 m^2/s^2}$$

$$\boxed{T_2 = 184,6°C}$$

$$v_2 = \frac{RT_2}{P_2} = \frac{0,287 \, . \, (184,6 + 273)}{100 kPa} = 1,313 \; m^3/kg$$

$$\dot{m} = \frac{1}{v_2} A_2 V_2 = 0,5304 = \frac{1}{1,313 m^3kg} \cdot A_2 \cdot (180 m/s) \Rightarrow$$

$$\boxed{A_2 = 38,7 cm^2}$$

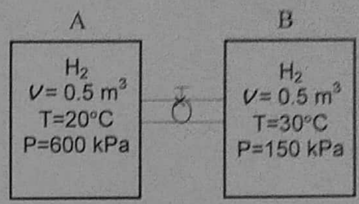
Şekildeki A ve B kapları vanayla birleşmektedir. Vana açılınca son durumdaki basıncı bulunuz?



**3-122** Two rigid tanks that contain hydrogen at two different states are connected to each other. Now a valve is opened, and the two gases are allowed to mix while achieving thermal equilibrium with the surroundings. The final pressure in the tanks is to be determined.

***Properties*** The gas constant for hydrogen is 4.124 kPa·m³/kg·K (Table A-1).

***Analysis*** Let's call the first and the second tanks A and B. Treating $H_2$ as an ideal gas, the total volume and the total mass of $H_2$ are




$$V = V_A + V_B = 0.5 + 0.5 = 1.0 \text{ m}^3$$

$$m_A = \left(\frac{P_1 V}{RT_1}\right)_A = \frac{(600 \text{ kPa})(0.5 \text{ m}^3)}{(4.124 \text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(293 \text{ K})} = 0.248 \text{ kg}$$

$$m_B = \left(\frac{P_1 V}{RT_1}\right)_B = \frac{(150 \text{ kPa})(0.5 \text{ m}^3)}{(4.124 \text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(303 \text{ K})} = 0.060 \text{ kg}$$

$$m = m_A + m_B = 0.248 + 0.060 = 0.308\text{kg}$$

Then the final pressure can be determined from

$$P = \frac{mRT_2}{V} = \frac{(0.308 \text{ kg})(4.124 \text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(288 \text{ K})}{1.0 \text{ m}^3} = \mathbf{365.8 \text{ kPa}}$$