Meeting_011

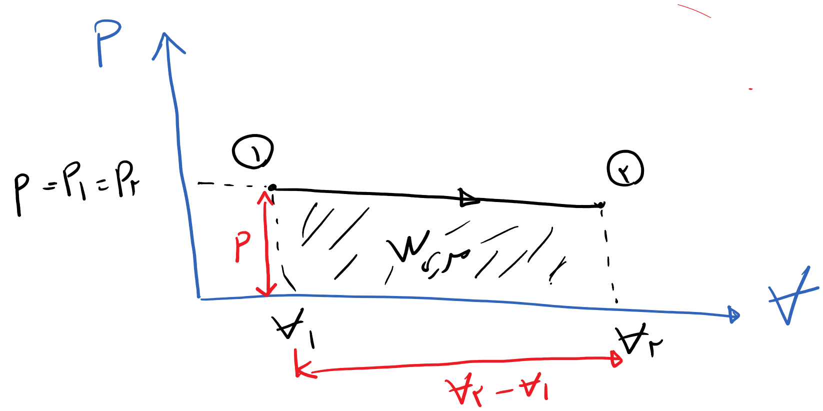
Monday, April 12, 2021 8:33 AM

کار مرزی

$$W_{\text{مرزی}} = \int_{V_1}^{V_2} p\,dV$$

فرایند فشار ثابت $\Longrightarrow$

$$W_{\text{مرزی}} = \int_{V_1}^{V_2} p\,dV = p\int_{V_1}^{V_2} dV = p(V_2 - V_1) = p\,\Delta V \quad \text{kJ}$$

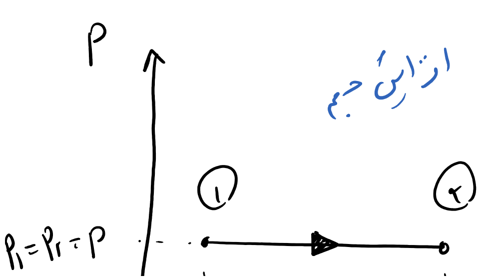


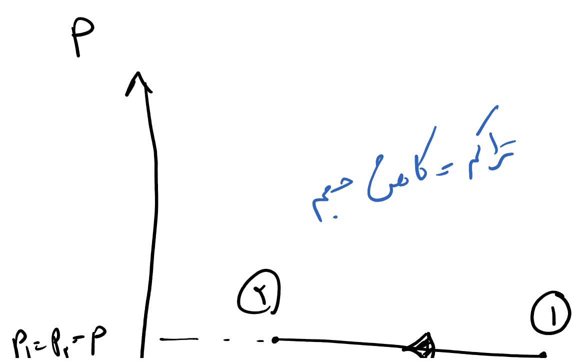
$$W_{\text{مرزی}} = p\,\Delta V \ (\text{kJ}) \longrightarrow W_{\text{مرزی}} = p\,\frac{\Delta V}{m} = p\left(\frac{V_2}{m} - \frac{V_1}{m}\right) = p(v_2 - v_1)$$

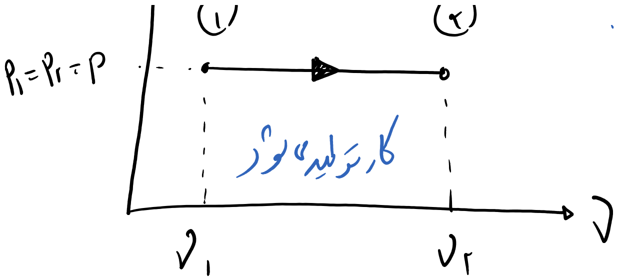
kJ/kg , $\frac{\Delta V}{m} = \Delta v$

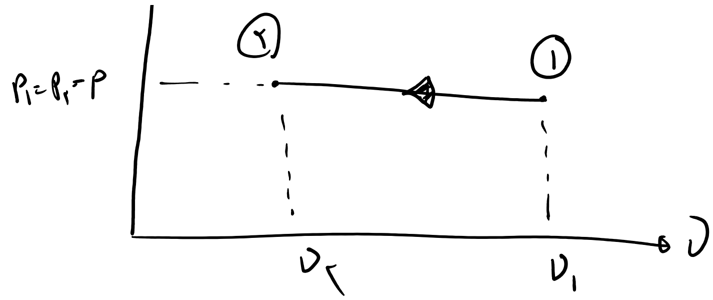
$$W_{\text{مرزی}} = p(v_2 - v_1) \quad \text{kJ/kg}$$

$$W_{\text{مرزی}} = m\,p(v_2 - v_1) \quad \text{kJ}$$





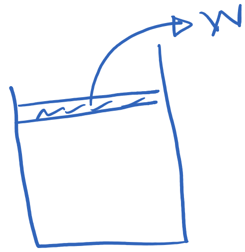


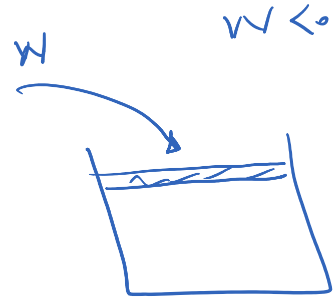


$W>0 \Rightarrow v_2 - v_1 > 0$

$v_2 - v_1 < 0$

$W<0 \rightarrow$ مصرف شده



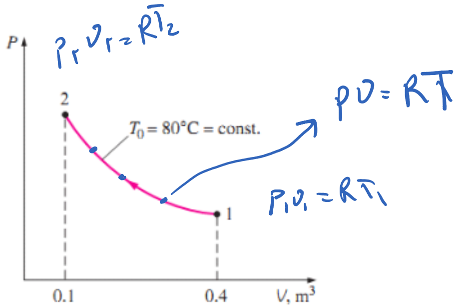


$T_1 = T_2 = T_3 = T_4$

محاسبه کار مصرفی برای گاز کامل در فرایند دما ثابت:

$$pv = RT \rightarrow P_1 v_1 = RT_1 \rightarrow P_1 v_1 = P_2 v_2 = P_3 v_3 = RT = \overset{\text{ثابت}}{C}$$

$pv =$ عدد ثابت $= C$



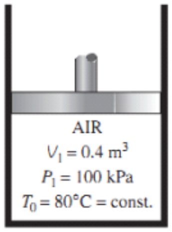
$$c = RT_1$$

$$c = P_1 v_1 \qquad c = P_2 v_2$$

$$pv = C \Rightarrow p = \frac{C}{v}$$

رابطه بین v, p

$$W_{\text{مصرفی}} = \int^{v_2} p\,dv = \int^{v_2} \frac{c}{v}\,dv = c\int_{v_1}^{v_2} \frac{dv}{v} = c\,Ln\frac{v_2}{v_1}$$



$$W_{\text{مرزی}} = \int_{v_1} p\,dv = \int_{v_1} \frac{c}{v}\,dv = c\int_{v_1} \frac{dv}{v} = c\,Ln\frac{v_2}{v_1}$$

kJ/kg

kJ/kg $$W_{\text{مرزی}} = c\,Ln\frac{v_2}{v_1} = RT_1\,Ln\frac{v_2}{v_1} = P_1 v_1\,Ln\frac{v_2}{v_1}$$

kJ $$W_{\text{مرزی}} = c\,Ln\frac{v_2}{v_1} = mRT_1\,Ln\frac{v_2}{v_1} = m P_1 v_1\,Ln\frac{v_2}{v_1} = P_1 \forall_1\,Ln\frac{v_2}{v_1}$$

$m v_1 = \forall_1$

kJ $$W_{\text{مرزی}} = mRT_1\,Ln\frac{v_2}{v_1} = P_1\forall_1\,Ln\frac{v_2}{v_1} = P_1\forall_1\,Ln\frac{\forall_2}{\forall_1}$$

EXAMPLE 4–3 Isothermal Compression of an Ideal Gas

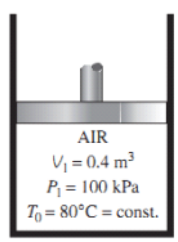
A piston–cylinder device initially contains 0.4 m³ of air at 100 kPa and 80°C. The air is now compressed to 0.1 m³ in such a way that the temperature inside the cylinder remains constant. Determine the work done during this process.

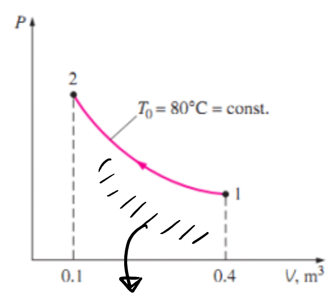
$\forall_1 = 0.4\,m^3$

جنس = هوا (گاز ایده‌آل)

$P_1 = 100\,kPa$

$T_1 = 80\,°C = 80 + 273 = 353\,K$





$A = W_{\text{مرزی}}$

حالت ۲

$\forall_2 = 0.1\,m^3$

$T_1 = T_2 \longrightarrow$ فرایند ثابت دما

$$W = P_1\forall_1\,Ln\frac{\forall_2}{\forall_1} = 100 \times 0.4\,Ln\frac{0.1}{0.4} = 40\,Ln\,0.25$$

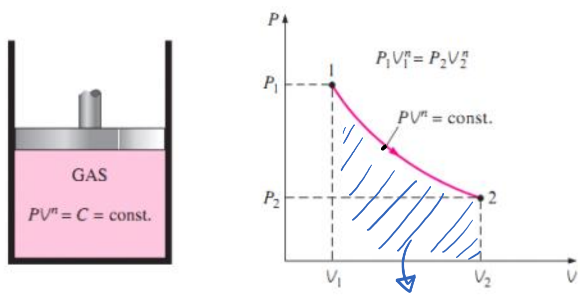
$$W_{\text{مرزی}} = P_1 V_1 \ln \frac{V_2}{V_1} = 100 \times 0.4 \ln \frac{0.1}{0.4} = 40 \ln 0.25$$

$$= -55.5 \ \text{kJ}$$

کار وارد سیستم شده است

Polytropic Process

فرایند پلی تروپیک در گاز کامل



$$P_1 v_1^n = P_2 v_2^n = P_3 v_3^n = \underset{(C)}{\text{ثابت}} = P v^n$$

$$K = n = \frac{C_p}{C_v}$$

$$P v^n = C \Rightarrow P = \frac{C}{v^n}$$

$\boxed{n-1}$

$$w_{\text{مرزی}} = \int_{v_1}^{v_2} P\,dv = \int_{v_1}^{v_2} \frac{C}{v^n}\,dv = C\int_{v_1}^{v_2} \frac{dv}{v^n} = C\int_{v_1}^{v_2} v^{-n}\,dv$$

$$= \left.\frac{C v^{-n+1}}{-n+1}\right|_{v_1}^{v_2} = C v_2^{-n+1} - C v_1^{-n+1} = \frac{P_2 v_2^n \, v_2^{-n+1}}{-n+1} - \frac{P_1 v_1^n \, v_1^{-n+1}}{-n+1}$$

$$= \frac{P_2 v_2 - P_1 v_1}{-n+1}$$

$$\left(\text{kJ/kg}\right) \quad w_k = \frac{P_2 v_2 - P_1 v_1}{\ldots}$$

$$\left(\text{kJ}\right) \quad W_{\text{مرزی}} = P_2 m v_2 - P_1 m v_1$$

(kJ/kg) $w_{\text{مرزی}} = \frac{P_2 v_2 - P_1 v_1}{-n+1}$

(kJ) $W_{\text{مرزی}} = P_2 m v_2 - P_1 m v_1 = \frac{P_2 V_2 - P_1 V_1}{-n+1}$

$$W_{\text{مرزی}} = \frac{P_2 V_2 - P_1 V_1}{-n+1} = \frac{mRT_2 - mRT_1}{-n+1} = \frac{mR(T_2 - T_1)}{-n+1} \quad (\text{kJ})$$

$P_1 V_1 = mRT_1$

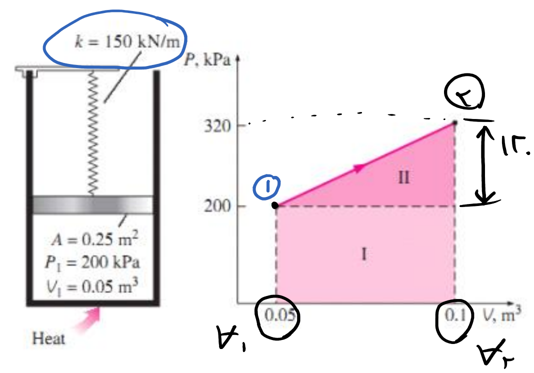
$P_2 V_2 = mRT_2$

$n = k = c_p / c_v$

$$W = ۲۰۰\,(۰/۱ - ۰/۰۵) + \tfrac{1}{2}\,(۰/۱ - ۰/۰۵)(۱۲۰) \ \text{kJ}$$

EXAMPLE 4–4 Expansion of a Gas against a Spring

A piston–cylinder device contains 0.05 m^3 of a gas initially at 200 kPa. At this state, a linear spring that has a spring constant of 150 kN/m is touching the piston but exerting no force on it. Now heat is transferred to the gas, causing the piston to rise and to compress the spring until the volume inside the cylinder doubles. If the cross-sectional area of the piston is 0.25 m^2, determine (*a*) the final pressure inside the cylinder, (*b*) the total work done by the gas, and (*c*) the fraction of this work done against the spring to compress it.



الف) فشار نهایی داخل سیلندر

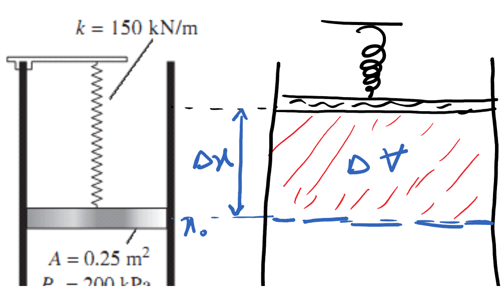
ب) کار مرزی کل انجام گرفته

$V_1 = ۰/۰۵\ \text{m}^3$

$P_1 = ۲۰۰\ \text{kPa}$

$V_2 = 2 V_1 = ۰/۱\ \text{m}^3$

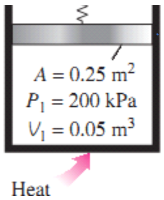
$A_p = ۰/۲۵\ \text{m}^2$

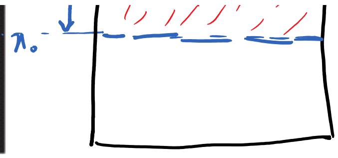


$\Delta V = A_p \cdot \Delta x$

$V_2 - V_1 = A_p \cdot \Delta x$

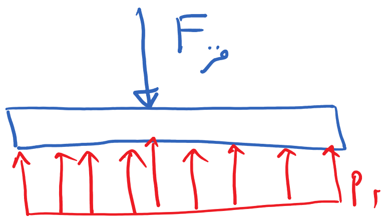
$۰/۱ - ۰/۰۵ = ۰/۲۵ \cdot \Delta x \rightarrow \Delta x = \frac{۰/۰۵}{۰/۲۵} = ۰/۲\ \text{m}$





$۰/۱ - ۰/۰۵ = ۰/۲۵ \Delta x \rightarrow \Delta x = \frac{\ldots}{۰/۲۵}$

$F_{فنر} = k \Delta x = ۱۵۰ \times ۰/۲ = ۳۰ \, kN$



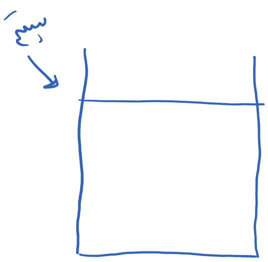
$F_{فنر} = P_۲ \cdot A_p$

$P_۲ = \frac{۳۰}{۰/۲۵} = ۱۲۰ \, kPa$

$P_۲ = فشار نهایی = P_۱ + P_۲ = ۲۰۰ + ۱۲۰ = ۳۲۰$

4–2 ▪ ENERGY BALANCE FOR CLOSED SYSTEMS

موازنه انرژی برای سیستم های بسته

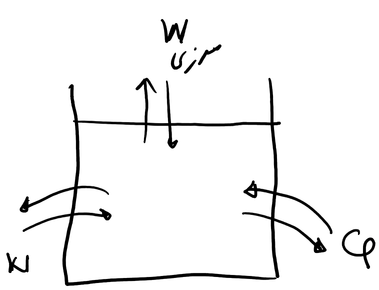


محتوای انرژی اولیه سیستم $= E_۱ = u_۱ + \frac{۱}{۲} V_۱^۲ + g z_۱$

سیستم فرایندی را طی می کند

محتوای انرژی سیستم در انتهای فرایند $E_۲ = u_۲ + ۱/۲ \, V_۲^۲ + g z_۲$

تغییرات انرژی سیستم در طی فرایند $\Rightarrow \Delta E = E_۲ - E_۱ = (u_۲ - u_۱) + ۱/۲ (V_۲^۲ - V_۱^۲) + g(z_۲ - z_۱)$



Q (kJ)	$\dot{Q}$ (kJ/s)	Δt (s)

$$\dot{Q} = \frac{Q}{\Delta t} \Rightarrow Q = \dot{Q} \Delta t$$ ✓

W (kJ) $\dot{W}$ (kJ/s = kW) Δt

$$\dot{W} = \frac{W}{\Delta t} \longrightarrow W = \dot{W} \Delta t$$