Meeting_010

Monday, April 05, 2021 10:05 AM

3–35 Complete this table for H_2O:

T, °C	P, kPa	u, kJ/kg	Phase description
	400	1450	
220			Saturated vapor
190	2500		
	4000	3040	

حسعیزی - الیاسی
قدیری - ساروی
کتابی - برزی
عیسی - فرنه

① $P = 400 \longrightarrow u_f = 604.22$ $\quad u_g = 2553.1$ $\quad T = T_{sat} = 143°C$

$u = 1450$

$u_f < u < u_g \longrightarrow$ مخلوط مایع - بخار

604.22 1948.9 2553.1

② بخار اشباع = فشار ثابت

$T = 220°C \Rightarrow P = P_{sat} = 2319.4$

$u = u_g = 2401$

③ $P = 2500\ kPa \longrightarrow T_{sat} = 223.95$

$T = 190°C$ $\quad T < T_{sat} \longrightarrow$ مایع متراکم

$T = 190°C \xrightarrow{\text{مایع اشباع}} u_f = 809$

$$\begin{cases} P = 4000 = 4\,MPa \longrightarrow u_f = 1082 \qquad u_g = 2601 \\ u = 3040 \end{cases}$$

1082.4 1519.3 2601.7

$u > u_g \longrightarrow$ بخار فوق گرم

$450 < T < 500$

THE IDEAL-GAS EQUATION OF STATE

گاز کامل:

معادله حالت (معادله گاز کامل)

حجم مخصوص

دمای مطلق (K)

$$Pv = RT \qquad (1)$$

فشار مطلق

ثابت گاز

ثابت عمومی

$$R = \frac{R_u}{M} \quad (\text{kJ/kg} \cdot \text{K or kPa} \cdot \text{m}^3/\text{kg} \cdot \text{K}) \qquad (2)$$

جرم مولکولی

$$R_u = \begin{cases} \boxed{8.31447\ \text{kJ/kmol} \cdot \text{K}} \\ 8.31447\ \text{kPa} \cdot \text{m}^3/\text{kmol} \cdot \text{K} \\ 0.0831447\ \text{bar} \cdot \text{m}^3/\text{kmol} \cdot \text{K} \\ 1.98588\ \text{Btu/lbmol} \cdot \text{R} \\ 10.7316\ \text{psia} \cdot \text{ft}^3/\text{lbmol} \cdot \text{R} \\ 1545.37\ \text{ft} \cdot \text{lbf/lbmol} \cdot \text{R} \end{cases}$$

$$R_{air} = \frac{R_u}{M} = \frac{8.31447}{29} = 0.286$$

$$R_{H_2O} = \frac{R_u}{M} = \frac{8.31447}{18} = 0.4619$$

$$\begin{cases} Pv = RT \longrightarrow P\cdot\dfrac{\forall}{m} = RT \longrightarrow \boxed{P\forall = mRT} \\ v = \dfrac{\forall}{m} \end{cases}$$

حجم جرم

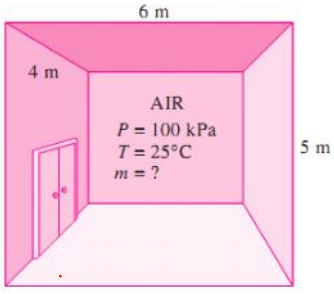
3

$$\begin{cases} P\forall = mRT \longrightarrow P\forall = n.M.\dfrac{R_u}{M}.T = nR_uT \\ m = n.M \quad 4 \\ R = \dfrac{R_u}{M} \end{cases} \Longrightarrow \boxed{P\forall = nR_u\cdot T} \quad 5$$

تعداد مولکول‌های گاز

EXAMPLE 3–10 Mass of Air in a Room

Determine the mass of the air in a room whose dimensions are 4 m × 5 m × 6 m at 100 kPa and 25°C.



$\forall = 4\times5\times6 = 20\times6 = 120\ m^3$

$P = 100\ kPa$

$T = 25°C + 273 = 298\ K$

$P\forall = mRT$

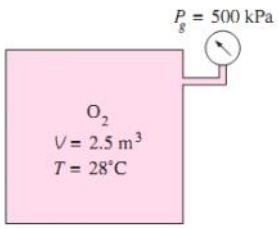
$100\times120 = m\cdot287\times(298) \rightarrow m = ?$

3–77 The pressure gage on a 2.5-m³ oxygen tank reads 500 kPa. Determine the amount of oxygen in the tank if the temperature is 28°C and the atmospheric pressure is 97 kPa.

$\forall = 2.5\ m^3 \qquad P_g = 500\ kPa$

P

kPa. Determine the amount of oxygen in the tank if the temperature is 28°C and the atmospheric pressure is 97 kPa.



$m = ?$

$P_{atm} = 97$ kPa $T = 28$ °C

$P_{abs} = P_g + P_{atm} = 500 + 97 = 597$ kPa

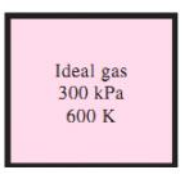
$T = 28 + 273 = 301$ K

$R = \frac{R_u}{M} = \frac{8.314}{32} = 0.2598$

$PV = mRT$

$597 \times 2.5 = m \times 0.2598 \times 301 \longrightarrow m = ?$

3–109 A rigid tank contains an ideal gas at 300 kPa and 600 K. Now half of the gas is withdrawn from the tank and the gas is found at 100 kPa at the end of the process. Determine (*a*) the final temperature of the gas and (*b*) the final pressure if no mass was withdrawn from the tank and the same final temperature was reached at the end of the process.



$P_1 = 300$ kPa $P_1 V_1 = m_1 R T_1$

$T_1 = 600$ K

$m_1 = ?$

$V_1 =$

$m_1 = \frac{P_1 V_1}{R T_1} = \frac{300 V_1}{600 R}$

$m_1 = \frac{V_1}{2R}$

$m_2 = \frac{1}{2} m_1 = \frac{1}{2} \times \frac{V_1}{2R} = \frac{V_1}{4R}$

$V_2 = V_1$

$P_2 = 100$ kPa

$T_2 = ?$

$P_2 V_2 = m_2 R T_2 \longrightarrow 100 \times \cancel{V_1} = \frac{\cancel{V_1}}{4\cancel{R}} \times \cancel{R} \cdot T_2 \longrightarrow T_2 = 400$ K

اگر هیچ جرمی از تانک خارج نشود و دمای تانک به 400K برسد، فشار در این حالت چقدر می‌باشد؟

$T_3 = 400\,K$

$m_3 = m_1 = \frac{V_1}{2R}$

$V_3 = V_1$

$P_3 = ?$

$P_3 V_3 = m_3 R T_3$

$P_3 \times V_1 = \frac{V_1}{2R} \cdot R \cdot (400) \Rightarrow P_3 = 200\,kPa$

تا این اینجا استفاده گرفته خواهد شد.

Chapter 4

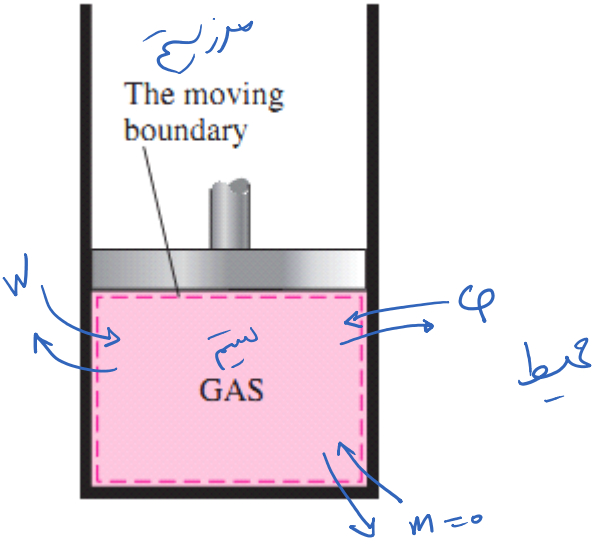
ENERGY ANALYSIS OF CLOSED SYSTEMS

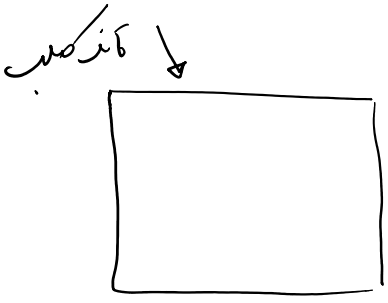
موازنه انرژی برای سیستم‌های بسته

مرز سیستم

متحرک ← سیلندر - پیستون

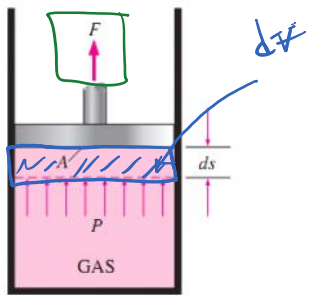
ثابت ← تانک صلب

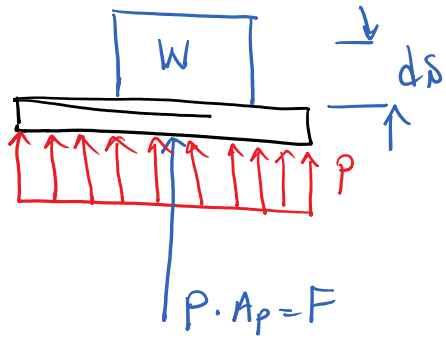




کار مرزی در سیستم های بسته

اگر مرز سیستم بسته متحرک باشد، کار مرزی در اثر حرکت مرز سیستم تولید یا مصرف می‌شود.

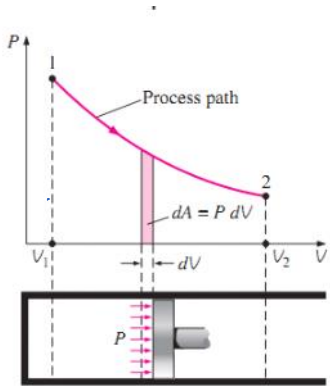




$$dW = F \cdot ds = P \cdot \underbrace{A_p \cdot ds} = P \cdot dV$$

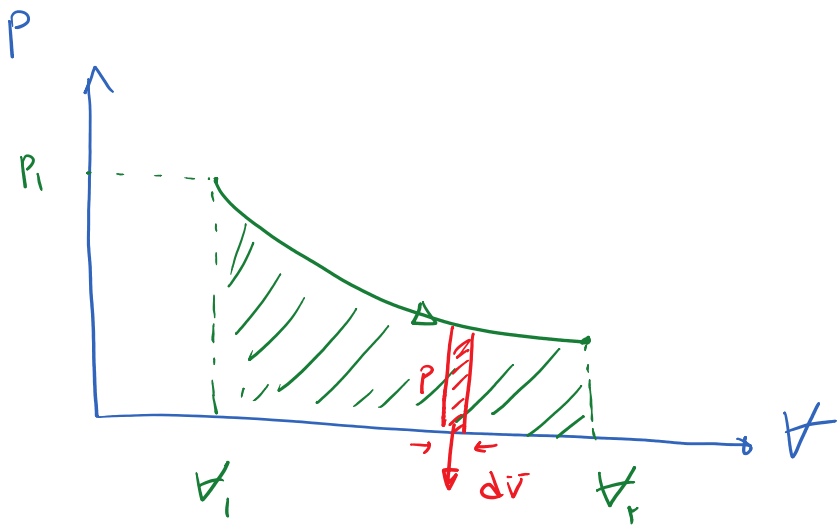
$$dW = P \cdot dV \longrightarrow \boxed{\begin{array}{l} \text{kJ} \\ W = \displaystyle\int_{V_1}^{V_2} \underset{\text{kPa}}{P}\, \underset{m^3}{dV} \end{array}}$$

از این رابطه برای محاسبه کار مرزی استفاده می‌کنیم و زمانی این رابطه قابل حل است که معادله یا رابطه بین P و V مشخص باشد.



$$W = \int p\, d\forall$$

کار مرزی در سیستم های بسته برابر با مساحت زیر منحنی $p\text{-}\forall$ می باشد



$$dA = p\, d\forall$$

$$A = \int dA = \int p\, d\forall$$

EXAMPLE 4–1 Boundary Work for a Constant-Volume Process

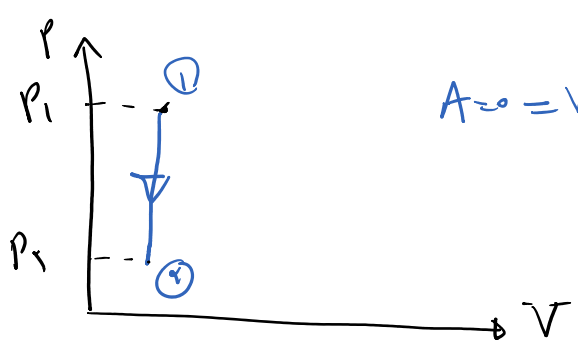
A rigid tank contains air at 500 kPa and 150°C. As a result of heat transfer to the surroundings, the temperature and pressure inside the tank drop to 65°C and 400 kPa, respectively. Determine the boundary work done during this process.

$\forall_1 = \forall_2$ ← تانک صلب

$\Delta\forall = 0$

$d\forall = 0$

سیستم بسته ⟶ کار مرزی ⟶ تانک صلب $d\forall = 0$ ⟶ $W_{\text{مرزی}} = \int p\, d\forall = 0$



$A = 0 = W_{\text{مرزی}}$

در داخل یک سیلندر-پیستون بخار آب اشباع با فشار 500 kpa وجود دارد. در اثر انتقال گرما به آن دمای آن در فشار ثابت به 300°C می‌رسد. کار مرزی سیستم را محاسبه کنید. (m=10 kg)

① فاز سیال = بخار اشباع

$P = 500\ kPa$

$\Longrightarrow$

$T_1 = T_{sat} = 151.83$

$v_1 = v_g = 0.374$

$u_1 = u_g = 2560$

$h_1 = h_g = 2748$

$s_1 = s_g = 6.820$ ✓

500	151.83	0.001093	0.37483	639.54	1921.2	2560.7	640.09	2108.0	2748.1	1.8604	4.9603	6.8207

② $P_2 = P_1 = 500\ kPa = 0.5\ MPa \longrightarrow T_{sat} = 151.86$

$T = 300°C$ $\quad T > T_{sat} \longrightarrow$ بخار فوق گرم

$\longrightarrow$

$v_2 = 0.52261$

$u_2 = 2803.3$

$h_2 = 3064.6$

$s_2 = 7.4614$

$P = 0.50$ MPa (151.83°C)

Sat.	0.37483	2560.7	2748.1	6.8207
200	0.42503	2643.3	2855.8	7.0610
250	0.47443	2723.8	2961.0	7.2725
300	0.52261	2803.3	3064.6	7.4614

v

$$W_{مرزی} = \int_{\forall_1}^{\forall_2} P\, d\forall = P \int_{\forall_1}^{\forall_2} d\forall = P \int_{v_1}^{v_2} m\, dv$$

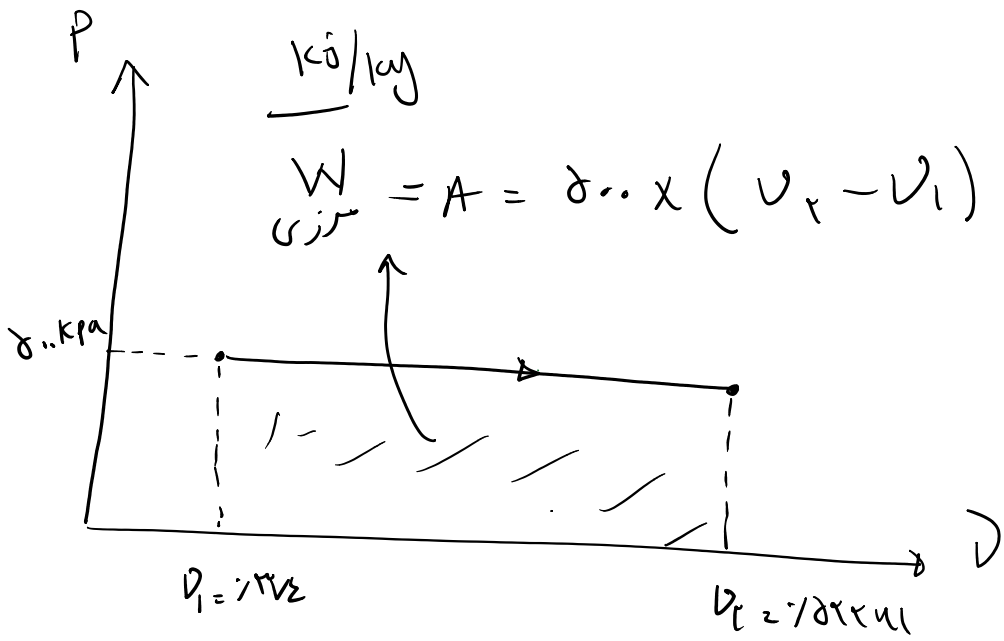
$$\forall = mv \qquad = 500 \times 10 \int_{v_1}^{v_2} dv = 500 \times 10 \cdot v \Big|_{v_1}^{v_2}$$

$\forall = mv$ $\quad = 500 \times 10 \int_{v_1} dv = 500 \times 10 \cdot v \Big|_{v_1}$

$d\forall \Rightarrow dv$

$= 500 \times 10 \, (v_2 - v_1)$

$W_{\text{مرزی}} = 500 \times 10 \, (0.3241 - 0.374)$



$kJ \quad W = 500 \times (v_2 - v_1) \times 10$

$W_{\text{مرزی}}$