Attendance: all but (Red)

\[ 2 - 73E \]

\[ \text{Air} / / \]

\[ \text{rigid} \rightarrow V = \text{const} \]

\[ \begin{align*}
M_1 &= 20 \text{ lbm} \\
P_1 &= 20 \text{ psia} \\
T_1 &= 70^\circ F = 530^\circ R
\end{align*} \]

\[ \text{Add mass} \rightarrow P_2 = 35 \text{ psia} \]

\[ T_2 = 90^\circ F = 550^\circ R \]

Find \( \Delta m \)

\[ \begin{align*}
V = \text{const} &= \frac{m \cdot RT}{P} \\
\frac{m_1 RT_1}{P_1} &= \frac{m_2 RT_2}{P_2} \\
\Delta m &= m_2 - m_1 = 13.73 \text{ lbm}
\end{align*} \]
\[ 2-\text{Eq} \quad V = 0.5 \text{m}^3 \quad \text{rigid} \Rightarrow V = \text{const} \]

Sat. mix @ 100°C

State 2 = critical state

Find: \( M_1 \), \( V_1 \)

\[
\begin{align*}
T &
\begin{array}{c}
100°C
\end{array}
\end{align*}
\]

\[
\begin{align*}
M_1 &= M_2 = M_{\text{crit}} \quad \text{(1.6729)}
\end{align*}
\]

\[
\begin{align*}
V_1 &= 0.003155 \text{ m}^3/\text{kg}
\end{align*}
\]

at \( T_1 = 100°C \)

\[
\begin{align*}
\chi_1 &= \frac{V_2 - V_1}{V_2} \quad \text{at} \quad 100°C
\end{align*}
\]

\[
\begin{align*}
\chi_1 &= \frac{M_2 - M_1}{M_{\text{tot}}}
\end{align*}
\]

\[
\begin{align*}
(1 - \chi_1) &= \frac{M_1}{M_{\text{tot}}}
\end{align*}
\]

\[
\begin{align*}
V_e &= M_1 \chi_1 \cdot V_2 = 1.58 \times 0.001044
\end{align*}
\]

\[
\begin{align*}
V_e &= 0.001 \text{ m}^3
\end{align*}
\]
Homework: due Friday
3-15 \( P = \text{const} \) 3-14
3-18 \( T = \text{const} \) (ATK!) 3-19
3-29 \( P = \text{const} \) \( h_u \)\( (P = \text{Linear}) \)
3-51

---

Review: Last Thing in Chpt 2.

3) Incompressible substance model
Solids and liquids

\[ \dot{q} = \text{const} \]

\[ C_p - C_v = 0 \Rightarrow C_p = C_v = C \]

"Equilibrium State"

\[ U_2 - U_1 = \int_{T_1}^{T_2} C_v \, dT = C(T_2 - T_1) \]

\[ h_2 - h_1 = w \] (\( w = U_2 - U_1 \) + \( P_2 v_2 - P_1 v_1 \))

\[ h_2 - h_1 = C(T_2 - T_1) + \delta (P_2 - P_1) \]
Ch 3 - Heat and Work

Heat and Work are both / each:

1) Energy in transition - a mode of energy transfer

2) Path functions - not exact differentials

depends on history of system, not just end states

\[
\delta Q = \Delta U + \Delta W
\]

\[
\Delta W = P \Delta V
\]

\[
W_{1\to 2} = \int_{V_1}^{V_2} P \, dV
\]

must know the path of system to integrate.

Properties are exact differentials

\[
\int_{V_1}^{V_2} P \, dV = U_2 - U_1
\]
Heat: Energy transfer due to a difference in temperature. Heat only flows from a higher T to a lower T.

3 modes/mechanisms for heat

1) Conduction

\[ Q = -k A \frac{dT}{dx} \]

\[ Q_{1-2} = \int_{T_1}^{T_2} Q \, dt \]

Specifies the mode of conduction

2) Convection

\[ Q = h A (T - T_{ref}) \]

Heat transfer coefficient

Specifies mode/mechanism relates heat to system states

3) Radiation

\[ Q = \varepsilon \sigma A (T^4 - T_{ref}^4) \]

Specifies mechanism for heat
Work: Force acting through distance

\[ W = \text{Force} \times \text{distance} \]

For our systems \( F = P \cdot A \)

\[ \delta W = F \delta x = P \left( \int A \, dA \right) = P dA \]

\[ W_{1-2} = \int_1^2 \delta W = \int_1^2 P dA \]

Simple compressible system

Specifies mode/mechanism for work.

Must know how \( P \) varies w/ \( V \).

(Other modes of work pg 138 &.)

Some classic cases

1) \( P = \text{const} \)

\[ W_{1-2} = P (V_2 - V_1) \]

2) \( \# = \text{const} \)

\[ W_{1-2} = \int_1^2 P dA = 0 \]

No work done if \( \# = \text{const} \)
3) \( P = \text{linear} = c + b\theta \)

\[
\begin{align*}
W_{1-2} &= \int P \, d\theta = \text{area} \\
&= \left( \frac{P_1 + P_2}{2} \right) (\theta_2 - \theta_1)
\end{align*}
\]

\( W_{1-2} = \text{avg height} \times \text{width} \)

4) Polytropic process \( \Rightarrow P V^n = \text{const} \)

As a model process that some system behavior approximates

\[
P_1 V_1^n = P_2 V_2^n
\]

\[
\frac{P_1}{P_2} = \left( \frac{V_2}{V_1} \right)^n = \left( \frac{\theta_2}{\theta_1} \right)^n
\]

\( \frac{P}{P_2} = \frac{\text{const}}{V^n} = \frac{\text{const}}{\theta^n} \)

\[
P = \frac{\text{const}}{V^n} = \text{const} \theta^{-n}
\]

\[
W_{1-2} = \int P \, d\theta = \int \text{const} \theta^{-n} \, d\theta = P_2 \frac{\theta_2^{1-n} - \theta_1^{1-n}}{1-n}
\]

\( \theta_1 = 1 \quad P_1 V_1 = \text{const} \)

\[
P = \text{const} / \theta
\]

\[
W_{1-2} = \int \frac{\text{const}}{\theta} \, d\theta = P \ln \frac{\theta_2}{\theta_1} = P \ln \frac{\theta_2}{\theta_1} = P_2 \ln \frac{P_1}{P_2}
\]

\( n = 1 \)