Ideal Gas Equation of State

$p \cdot \upsilon = R \cdot T$ — Ideal gas law

$u = u(T)$ — Specific internal energy depends on T *ONLY*

$h = h(T) = u(T) + R \cdot T$ — Specific enthalpy of an ideal gas depends on T *ONLY*

$c_V(T) = \dfrac{R}{k - 1}$ — Specific heat of an ideal gas

Process 1a: Heat a fixed volume of air

State (1a)

$T_{1a} := 300K$ $\qquad h(300K) = 300.19 \dfrac{kJ}{kg}$

$P_{1a} := 1atm$

$\upsilon_{1a} := 1 \dfrac{m^3}{kg}$

State (2a)

$T_{2a} := 400K$ $\qquad h(400K) = 400.98 \dfrac{kJ}{kg}$

$\upsilon_{2a} := \upsilon_{1a}$

$$\frac{R \cdot T_{1a}}{P_{1a}} = \frac{R \cdot T_{2a}}{P_{2a}} \text{ solve}, P_{2a} \rightarrow \frac{4 \cdot atm}{3}$$

Process 1b: Expand the pressurized air

State (3)

$T_3 := 400K$ $\qquad h(400K) = 400.98 \dfrac{kJ}{kg}$

$P_3 := \dfrac{4}{3} \cdot atm$

$\upsilon_3 := 1 \dfrac{m^3}{kg}$

State (4)

$P_4 := 1.0atm$

$\upsilon_4 := \dfrac{4}{3} \dfrac{m^3}{kg}$

$$\frac{P_3 \cdot \upsilon_3}{T_3} = \frac{P_4 \cdot \upsilon_4}{T_4} \text{ solve}, T_4 \rightarrow 400.0 \cdot K \qquad h(400K) = 400.98 \frac{kJ}{kg}$$

Process 2: Heat a free volume of air

State (1)

$T_{1b} := 300K$ $\qquad h(300K) = 300.19\,\frac{kJ}{kg}$

$P_{1b} := 1.0atm$

$\upsilon_{1b} := 1\,\frac{m^3}{kg}$

State (2)

$T_{2b} := 400K$ $\qquad h(400K) = 400.98\,\frac{kJ}{kg}$

$P_{2b} := P_{1b}$

$$\frac{R \cdot T_{1b}}{\upsilon_{1b}} = \frac{R \cdot T_{2b}}{\upsilon_{2b}} \text{ solve}, \upsilon_{2b} \rightarrow \frac{4 \cdot m^3}{3 \cdot kg}$$