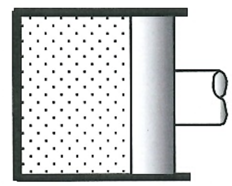
Example



A piston-cylinder contains 1.5 kg of air. Initially, the air is at 150 kPa and 20°C. The air is compressed in an *isobaric process* (and that means...) until the volume is 1 m^3. Assume that air is an ideal gas, but **do not assume that the specific heats are constant**. If the compression is quasistatic,

a) find the work into the system, in kJ, and
b) the heat transfer into the system, in kJ.

a) WORK IS Compression - expansion work:

$$W_{12} = -\int_1^2 P\,d\forall = -P\int_1^2 d\forall = -P\forall\Big|_1^2 = -P\left[\forall_2 - \forall_1\right]$$

ISOBARIC

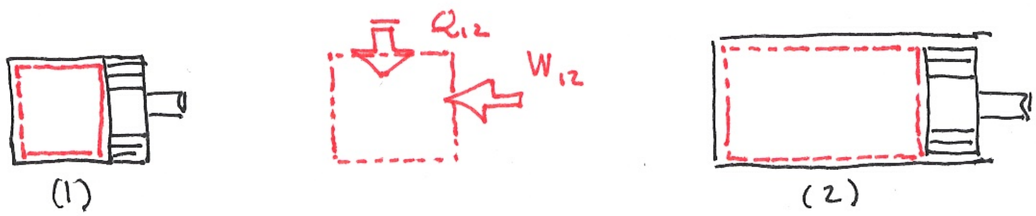
AT (1) $P_1\forall_1 = mRT_1 \Rightarrow \forall_1 = \frac{mRT_1}{P_1} = \frac{(1.5\text{ kg})(0.287\ \frac{\text{kJ}}{\text{kg}\cdot\text{K}})(20°\text{C} + 273)}{150\text{ kPa}} \left\langle \frac{\text{kJ}}{\text{kPa}\cdot\text{m}^3} \right\rangle$

$$= 0.84\text{ m}^3$$

$$W_{12} = -150\text{ kPa}\left[1\text{ m}^3 - 0.84\text{ m}^3\right] = -23.9\text{ kPa}\cdot\text{m}^3$$

$$= \boxed{23.9\text{ kJ OUT}}$$

b) C.O.E. (1) TO (2) Finite time



$$\frac{dE_{sys}}{dt} = \dot{Q} + \dot{W} + \cancel{\ \ }_0 - \cancel{\ \ }_0$$

CLOSED SYSTEM

$$\int_{E_1}^{E_2} dE_{sys} = \int_{t_1}^{t_2} \dot{Q}\,dt + \int_{t_1}^{t_2} \dot{W}\,dt$$

$E_2 - E_1 = Q_{1\to2} + W_{1\to2}$ ONLY U IMPORTANT $U_2 - U_1 = Q_{12} + W_{1\to2}$

$$m(u_2 - u_1) = Q_{12} + W_{12}$$

$$Q_{12} = m(u_2 - u_1) - W_{12} = m[u(T_2) - u(T_1)] - W_{12}$$

NEED T_2

$$P_2 \forall_2 = mRT_2 \qquad T_2 = \frac{P_2 \forall_2}{mR} = \frac{P \forall_2}{mR} = \frac{(150\ kPa)(1.0\ m^3)}{(1.5\ kg)(0.287\ \frac{kJ}{kg\text{-}K})}$$

$$= 348.43\ K$$

!!!

FROM TABLE A-22

$T_2 = 348.43\ K \qquad u(T_2) = 248.9\ kJ/kg$

$T_1 = 293\ K \qquad u(T_1) = 209.1\ kJ/kg$

$$Q_{12} = 1.5\ kg\ (248.9 - 209.1)\ \frac{kJ}{kg} - (-23.9\ kJ)$$

$$= \boxed{83.6\ kJ}$$