8-181 Air is compressed in a piston-cylinder device. It is to be determined if this process is possible.

Assumptions **1** Changes in the kinetic and potential energies are negligible. **4** Air is an ideal gas with constant specific heats. **3** The compression process is reversible.

Properties The properties of air at room temperature are R = 0.287 kPa·m^3/kg·K, c_p = 1.005 kJ/kg·K (Table A-2a).

Analysis We take the contents of the cylinder as the system. This is a closed system since no mass enters or leaves. The energy balance for this stationary closed system can be expressed as

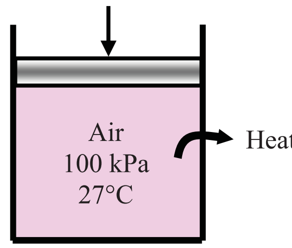
$$\underbrace{E_{in} - E_{out}}_{\substack{\text{Net energy transfer}\\ \text{by heat, work, and mass}}} = \underbrace{\Delta E_{system}}_{\substack{\text{Change in internal, kinetic,}\\ \text{potential, etc. energies}}}$$

$$W_{b,in} - Q_{out} = \Delta U = m(u_2 - u_1)$$

$$W_{b,in} - Q_{out} = mc_p(T_2 - T_1)$$

$$W_{b,in} - Q_{out} = 0 \quad (\text{since } T_2 = T_1)$$

$$Q_{out} = W_{b,in}$$



The work input for this isothermal, reversible process is

$$w_{in} = RT\ln\frac{P_2}{P_1} = (0.287\text{ kJ/kg}\cdot\text{K})(300\text{ K})\ln\frac{250\text{ kPa}}{100\text{ kPa}} = 78.89\text{ kJ/kg}$$

That is,

$$q_{out} = w_{in} = 78.89\text{ kJ/kg}$$

The entropy change of air during this isothermal process is

$$\Delta s_{air} = c_p\ln\frac{T_2}{T_1} - R\ln\frac{P_2}{P_1} = -R\ln\frac{P_2}{P_1} = -(0.287\text{ kJ/kg}\cdot\text{K})\ln\frac{250\text{ kPa}}{100\text{ kPa}} = -0.2630\text{ kJ/kg}\cdot\text{K}$$

The entropy change of the reservoir is

$$\Delta s_R = \frac{q_R}{T_R} = \frac{78.89\text{ kJ/kg}}{300\text{ K}} = 0.2630\text{ kJ/kg}\cdot\text{K}$$

Note that the sign of heat transfer is taken with respect to the reservoir. The total entropy change (i.e., entropy generation) is the sum of the entropy changes of air and the reservoir:

$$\Delta s_{total} = \Delta s_{air} + \Delta s_R = -0.2630 + 0.2630 = \mathbf{0\ kJ/kg\cdot K}$$

Not only this process is possible but also completely reversible.