

MINIMIZING THE COMPRESSOR WORK

$$w_{\text{rev,in}} = \int_1^2 v \, dP$$

When kinetic and potential energies are negligible

Isentropic ($Pv^k = \text{constant}$):

$$w_{\text{comp,in}} = \frac{kR(T_2 - T_1)}{k - 1} = \frac{kRT_1}{k - 1} \left[\left(\frac{P_2}{P_1} \right)^{(k-1)/k} - 1 \right]$$

Polytropic ($Pv^n = \text{constant}$):

$$w_{\text{comp,in}} = \frac{nR(T_2 - T_1)}{n - 1} = \frac{nRT_1}{n - 1} \left[\left(\frac{P_2}{P_1} \right)^{(n-1)/n} - 1 \right]$$

Isothermal ($Pv = \text{constant}$):

$$w_{\text{comp,in}} = RT \ln \frac{P_2}{P_1}$$

The adiabatic compression ($Pv^k = \text{constant}$) requires the maximum work and the isothermal compression ($T = \text{constant}$) requires the minimum. **Why?**

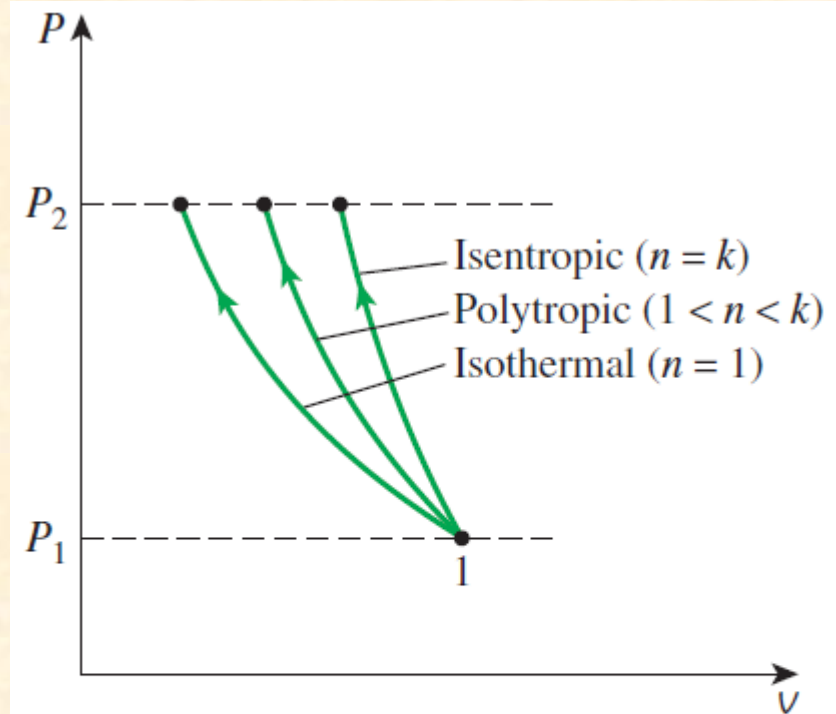


FIGURE 7-44

P - v diagrams of isentropic, polytropic, and isothermal compression processes between the same pressure limits.

Multistage Compression with Intercooling

The gas is compressed in stages and cooled between each stage by passing it through a heat exchanger called an *intercooler*.

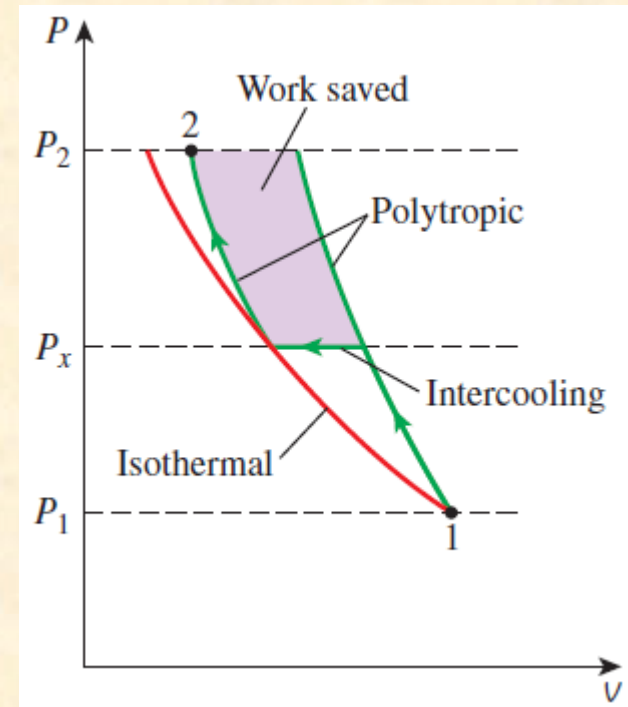
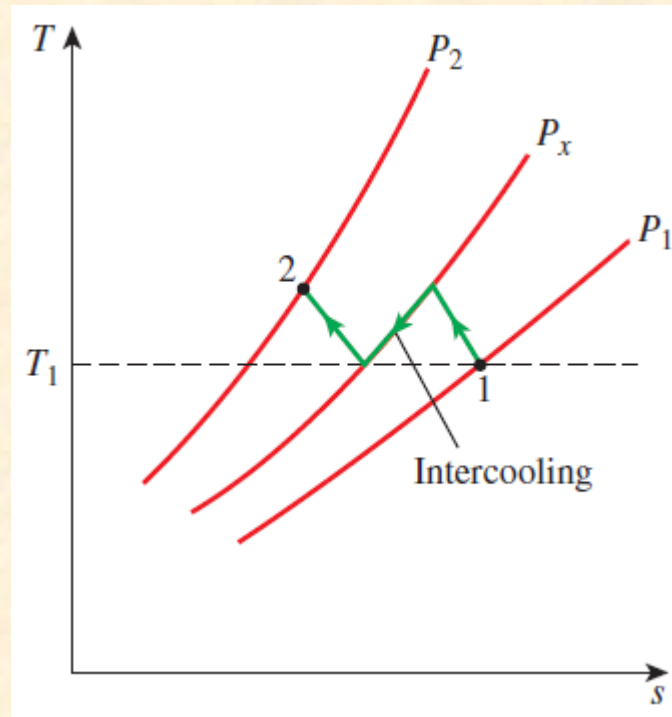


FIGURE 7–45

P-v and T-s diagrams for a two-stage steady-flow compression process.

$$W_{\text{comp, in}} = W_{\text{comp I, in}} + W_{\text{comp II, in}}$$

$$= \frac{nRT_1}{n-1} \left[\left(\frac{P_x}{P_1} \right)^{(n-1)/n} - 1 \right] + \frac{nRT_1}{n-1} \left[\left(\frac{P_2}{P_x} \right)^{(n-1)/n} - 1 \right]$$

$$P_x = (P_1 P_2)^{1/2} \quad \text{or} \quad \frac{P_x}{P_1} = \frac{P_2}{P_x}$$

To minimize compression work during two-stage compression, the pressure ratio across each stage of the compressor must be the same.