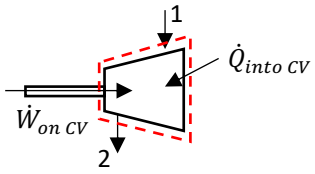
An air compressor operates at steady-state with air entering at p_1= 15 psfa and T_1= 60 °F. The air undergoes a polytropic process and exits at p_2 = 75 psfa and T_2 = 294 °F.

a. Evaluate the exponent for the polytropic process.
b. Sketch the process on a *p*-*v* diagram.

SOLUTION:



Since the process is polytropic,

$$p_1 v_1^n = c = p_2 v_2^n \Rightarrow \frac{p_2}{p_1} = \left(\frac{v_1}{v_2}\right)^n, \quad (1)$$

where *c* is a constant and *n* is currently unknown. With the air treated as an ideal gas,

$$pv = RT \Rightarrow \frac{v_1}{v_2} = \frac{T_1 p_2}{T_2 p_1}, \quad (2)$$

and combining with Eq. (1),

$$\frac{p_2}{p_1} = \left(\frac{T_1 p_2}{T_2 p_1}\right)^n \Rightarrow \ln\left(\frac{p_2}{p_1}\right) = n \ln\left(\frac{T_1 p_2}{T_2 p_1}\right) \Rightarrow \boxed{n = 1.30}, \quad (3)$$

using the given values of,

p_1 = 15 psfa, p_2 = 75 psfa, T_1 = 60 °F = 519.67 °R, T_2 = 294 °F = 753.67 °R.

The specific volumes at the inlet and outlet may be found using Eq. (2) with R_{air} = 53.3533 ft.lb$_f$/(lb$_m$. °R),

v_1 = 1850 ft^3/lb$_m$ and v_2 = 536 ft^3/lb$_m$.