**PROBLEM 6.122**

Air in a piston-cylinder assembly is compressed isentropically from $T_1 = 60^\circ F$, $p_1 = 20$ lbf/in$^2$ to $p_2 = 2000$ lbf/in$^2$. Assuming the ideal gas model, determine the temperature at state 2, in °F, using (a) data from Table A-22E, and (b) a constant specific heat ratio, $k = 1.4$. Compare the values obtained in parts (a) and (b) and comment.

**ENGINEER MODEL**

1. The air is the closed system.
2. The air undergoes an isentropic process.
3. The air is modeled as an ideal gas.

(a) \[ \frac{p_2}{p_1} = \frac{P_r(2)}{P_r(1)} \Rightarrow P_r(2) = P_r(1) \left( \frac{121.4/7}{30} \right) = 121.47 \text{ lbf/in}^2 \]

Interpolating in Table A-22E gives, $T_2 = 1828$ °R

(b) With Eq. 6.48,

\[ T_2 = T_1 \left( \frac{p_2}{p_1} \right)^{k-1} = 520 \text{ °R} \left( \frac{121.47}{30} \right)^{0.4} = 1938 \text{ °R} \]

The value obtained in part (b) is about 6% greater than in part (a).

The approach in part (a) accounts for the variation of specific heats with temperature whereas the approach in part (b) does not.

**PROBLEM 6.123**

Air in a piston-cylinder assembly is compressed isentropically from state 1, where $T_1 = 35^\circ C$, to state 2, where the specific volume is one-tenth of the specific volume at state 1. Applying the ideal gas model with $k = 1.4$, determine (a) $T_2$, in °C and (b) the work, in kJ/kg.

**ENGINEER MODEL**

1. The air is the closed system.
2. The air undergoes an isentropic process.
3. The air is modeled as an ideal gas with $k = 1.4$.
4. Kinetic and potential energy play no role.

**ANALYSIS**

(a) With Eq. 6.49,

\[ T_2 = T_1 \left( \frac{V_2}{V_1} \right)^{k-1} = (308.15 \text{ K}) \left( \frac{1}{10} \right)^{0.4} = 774.07 \text{ K} \ (500.9^\circ \text{ C}) \]

(b) Reducing an energy balance for the adiabatic process,

\[ \Delta U + \Delta E = 0 \Rightarrow W = -\Delta U = -mc_v(T_2 - T_1) \]

From Eq. 3.47, $c_v = R/(k-1)$. So

\[ W = -\frac{R}{(k-1)} \left( T_2 - T_1 \right) = \frac{1.4}{2.73} \left( 308.15 - 774.07 \right) \frac{\text{kJ}}{\text{kJ}} = -33.43 \frac{\text{kJ}}{\text{kJ}} \]