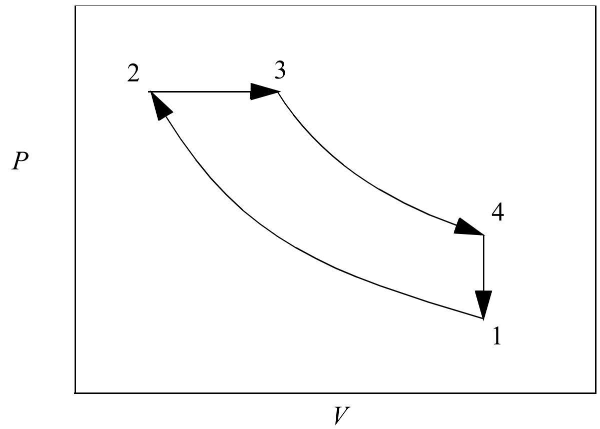

Figure 4.18 *Schematic of air-standard Diesel cycle.*

Example 4.9 Thermal efficiency of a Diesel engine

Develop an expression for the thermal efficiency of the air-standard diesel cycle as a function of the compression ratio $rc = V_1/V_2$ and the expansion ratio $re = V_4/V_3$. Assume the working fluid is an ideal gas, and the volume effect of moles of gas generated is small relative to the effect of heating from combustion.

Solution: This process is a little more complicated than the Otto cycle because of the heat addition at constant pressure. Since the volume is changing, the energy balance for the combustion is:

$$Q_H + W_{S,comb} = dU \Rightarrow \Delta U - W_{S,comb} = \Delta U + P_H(V_3 - V_2) = \Delta(U + PV) = \Delta H$$

$$\Rightarrow Q_H = \Delta H = C_P(T_3 - T_2) \quad (*ig)$$

$$Q_C = C_V(T_1 - T_4) \quad (*ig)$$

$$-W_{S,net}/Q_H = (Q_H + Q_C)/Q_H = 1 + \frac{C_V(T_1 - T_4)}{C_P(T_3 - T_2)} = 1 + \frac{1}{\gamma}\left[\frac{T_1}{T_3 - T_2} - \frac{T_4}{T_3 - T_2}\right] \quad (*ig)$$

$$\frac{T_3 - T_2}{T_1} = \frac{T_3}{T_1} - \frac{T_2}{T_1} = \frac{P_3V_3}{P_1V_1} - rc^{\gamma-1} = rc^{\gamma}/re - rc^{\gamma-1} \quad (*ig)$$

$$\frac{T_3 - T_2}{T_4} = \frac{T_3}{T_4} - \frac{T_2}{T_4} = re^{\gamma-1} - \frac{P_2V_2}{P_4V_4} = re^{\gamma-1} - \frac{P_3V_2}{P_4V_4} = re^{\gamma-1} - re^{\gamma}/rc \quad (*ig)$$

$$\begin{aligned}\eta &= 1 + \frac{1}{\gamma}\left\{\frac{1}{rc^{\gamma}/re - rc^{\gamma-1}} - \frac{1}{re^{\gamma-1} - re^{\gamma}/rc}\right\} \\ &= 1 + \frac{1}{\gamma}\left\{\frac{re}{rc^{\gamma} - re\cdot rc^{\gamma-1}} - \frac{rc}{rc\cdot re^{\gamma-1} - re^{\gamma}}\right\}\end{aligned} \quad (*ig)\ 4.9$$