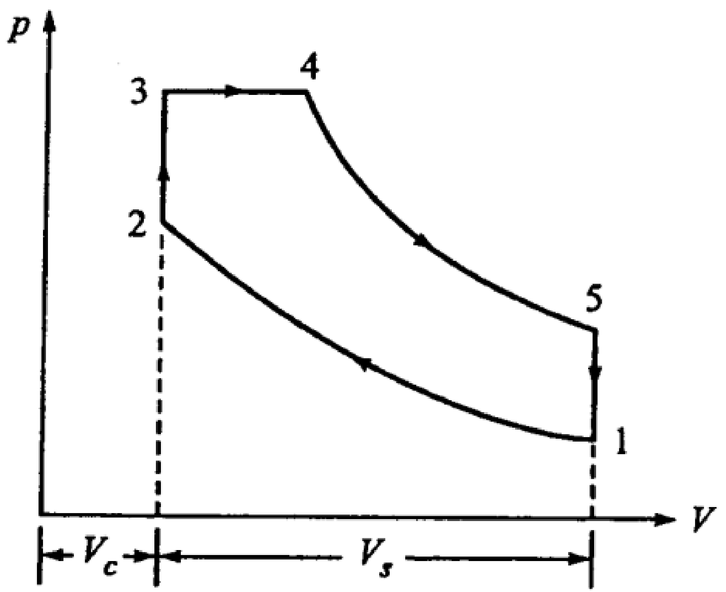
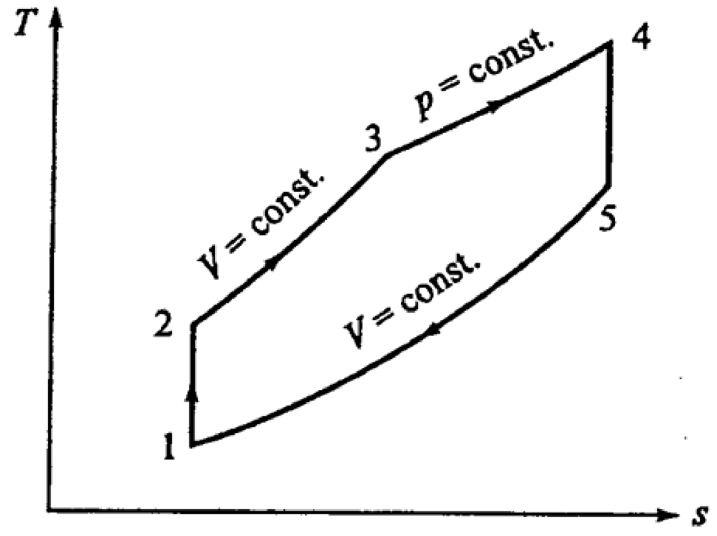
DUAL COMBUSTION CYCLE



(a) p–V diagram



(b) T–s diagram

Heat supplied during the process 2–3 $= mc_v (T_3 - T_2)$

Heat supplied during the process 3–4 $= mc_p (T_4 - T_3)$

Total heat supplied, $Q_1 = mc_v (T_3 - T_2) + mc_p (T_4 - T_3)$

Heat rejected during process 5–1, $Q_2 = mc_v (T_5 - T_1)$

Thermal efficiency, $\eta = 1 - \dfrac{Q_2}{Q_1}$

$$= 1 - \frac{mc_v(T_5 - T_1)}{mc_v(T_3 - T_2) + mc_p(T_4 - T_3)}$$

$$= 1 - \frac{T_5 - T_1}{(T_3 - T_2) + \gamma (T_4 - T_3)}$$

Three ratios are used to analyse the Dual combustion cycle:

(1) Compression ratio, $r = \dfrac{V_1}{V_2}$

(2) Pressure ratio, $\alpha = \dfrac{p_3}{p_2}$

(3) Cut-off ratio, $\beta = \dfrac{V_4}{V_3}$

These ratios are always greater than 1.

For isentropic process 1–2,

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = r^{\gamma-1}$$

$$T_2 = T_1 r^{\gamma-1}$$

For constant volume process 2–3,

$$\frac{p_2}{T_2} = \frac{p_3}{T_3}$$

$$T_3 = \frac{p_3}{p_2} T_2 = \alpha T_2 = \alpha T_1 r^{\gamma-1}$$

For constant pressure process 3–4,

$$\frac{V_3}{T_3} = \frac{V_4}{T_4}$$

$$T_4 = \frac{V_4}{V_3} T_3 = \beta T_3 = \beta \alpha T_1 r^{\gamma-1}$$

For isentropic process 4–5,

$$\frac{T_5}{T_4} = \left(\frac{V_4}{V_5}\right)^{\gamma-1} = \left(\frac{V_4}{V_3} \cdot \frac{V_3}{V_5}\right)^{\gamma-1} = \left(\frac{V_4}{V_3} \cdot \frac{V_2}{V_1}\right)^{\gamma-1} = \left(\frac{\beta}{r}\right)^{\gamma-1}$$

$$\therefore \quad T_5 = T_4 \left(\frac{\beta}{r}\right)^{\gamma-1} = \beta\alpha T_1 r^{\gamma-1}\left(\frac{\beta}{r}\right)^{\gamma-1} = \alpha\beta^{\gamma} T_1$$

$$\eta = 1 - \frac{(\alpha\beta^{\gamma} T_1 - T_1)}{(\alpha T_1 r^{\gamma-1} - T_1 r^{\gamma-1}) + \gamma(\beta\alpha T_1 r^{\gamma-1} - \alpha T_1 r^{\gamma-1})}$$

$$= 1 - \frac{\alpha\beta^{\gamma} - 1}{r^{\gamma-1}[(\alpha - 1) + \alpha\gamma(\beta - 1)]}$$