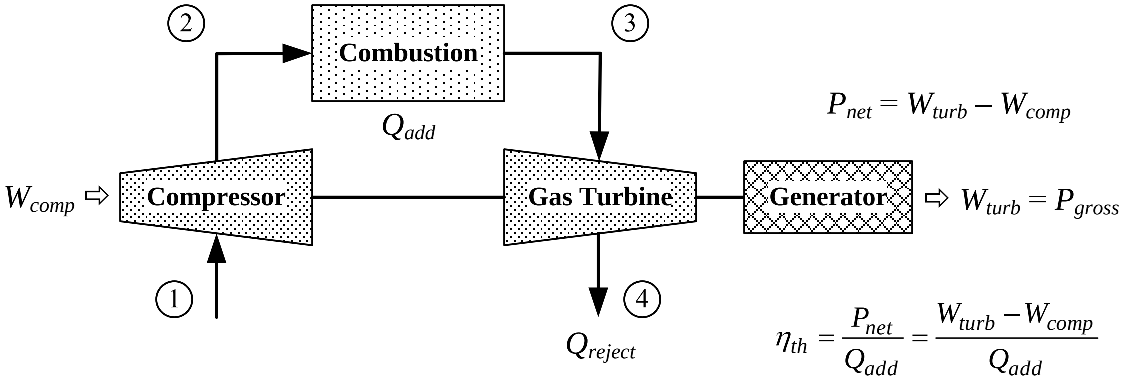


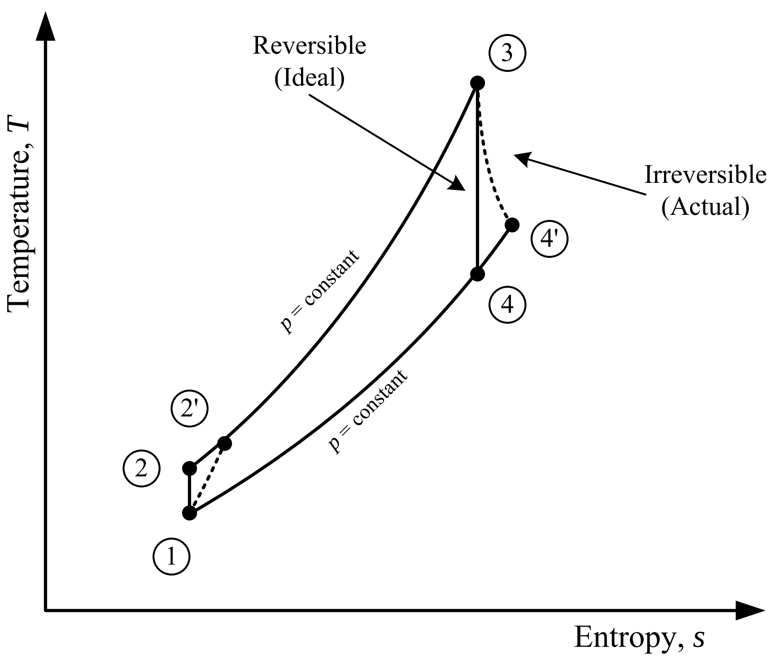
$$P_{net} = W_{turb} - W_{comp}$$

$$\eta_{th} = \frac{P_{net}}{Q_{add}} = \frac{W_{turb} - W_{comp}}{Q_{add}}$$

$$\eta_{th}^{ideal} = 1 - \frac{1}{r_p^{(k-1)/k}}$$

mass flow rate: $\dot{m}$

volume flow rate: $G = v\,\dot{m} = \dot{m} / \rho$



Turbine/Compressor Pressure Ratio (r_p):

$$r_p = \frac{p_{\max}}{p_{\min}}$$

$$\frac{T_3}{T_4} = r_{pT}^{(k-1)/k} = \left(\frac{p_3}{p_4}\right)^{(k-1)/k}$$

$$\frac{T_2}{T_1} = r_{pC}^{(k-1)/k} = \left(\frac{p_2}{p_1}\right)^{(k-1)/k}$$

$$k = c_p / c_v$$

①→②; <u>Compressor</u>: ($Q = 0$; $s_2 = s_1$)

$$W_{comp}^{ideal} = \dot{m}\,(h_2 - h_1) \cong \dot{m}\,c_p\,(T_2 - T_1)$$

$$= \dot{m}\,c_p\,T_2\left(1 - \frac{T_1}{T_2}\right) = \dot{m}\,c_p\,T_2\left(1 - \frac{1}{r_p^{(k-1)/k}}\right)$$

$$W_{comp}^{actual} = \dot{m}\,(h_{2'} - h_1) \cong \dot{m}\,c_p\,(T_{2'} - T_1)$$

$$\eta_{comp} = \frac{W_{comp}^{ideal}}{W_{comp}^{actual}} = \frac{\Delta h_{ideal}}{\Delta h_{actual}} = \frac{h_2 - h_1}{h_{2'} - h_1} \cong \frac{T_2 - T_1}{T_{2'} - T_1}$$

③→④; <u>Turbine</u>: ($Q = 0$; $s_4 = s_3$)

$$W_{turb}^{ideal} = \dot{m}\,(h_3 - h_4) \cong \dot{m}\,c_p\,(T_3 - T_4)$$

$$= \dot{m}\,c_p\,T_3\left(1 - \frac{T_4}{T_3}\right) = \dot{m}\,c_p\,T_3\left(1 - \frac{1}{r_p^{(k-1)/k}}\right)$$

$$W_{turb}^{actual} = \dot{m}\,(h_3 - h_{4'}) \cong \dot{m}\,c_p\,(T_3 - T_{4'})$$

$$\eta_{turb} = \frac{W_{turb}^{actual}}{W_{turb}^{ideal}} = \frac{\Delta h_{actual}}{\Delta h_{ideal}} = \frac{h_3 - h_{4'}}{h_3 - h_4} \cong \frac{T_3 - T_{4'}}{T_3 - T_4}$$

②→③; <u>Heating</u>: ($W = 0$)

$$Q_{add} = \dot{m}\,(h_3 - h_{2/2'}) \cong \dot{m}\,c_p\,(T_3 - T_{2/2'})$$

④→①; <u>Environment</u>: ($W = 0$)

$$Q_{reject} = \dot{m}\,(h_{4/4'} - h_1) \cong \dot{m}\,c_p\,(T_{4/4'} - T_1)$$

The use of the approximately equal symbol (≅) in the above equations denotes that c_p must be constant.