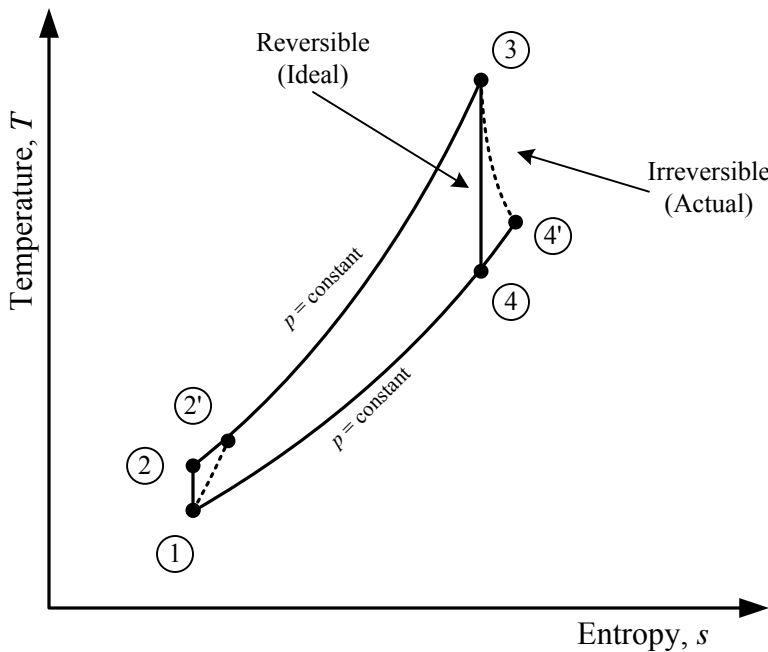


mass flow rate : \dot{m}
 volume flow rate : $G = v \dot{m} = \dot{m} / \rho$

$$P_{net} = P_{gross} - \dot{W}_{comp} = \dot{W}_{turb} - \dot{W}_{comp}$$

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

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



Turbine/Compressor Pressure Ratio (r_p):

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

$$\frac{T_3}{T_4} = r_p^{(k-1)/k} = \left(\frac{P_3}{P_4} \right)^{(k-1)/k}$$

$$\frac{T_2}{T_1} = r_p^{(k-1)/k} = \left(\frac{P_2}{P_1} \right)^{(k-1)/k}$$

$$k = c_p / c_v$$

①→②; Compressor: ($Q = 0; s_2 = s_1$)

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

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

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

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

②→③; Heating: ($W = 0$)

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

③→④; Turbine: ($Q = 0; s_4 = s_3$)

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

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

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

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

④→①; Environment: ($W = 0$)

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

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