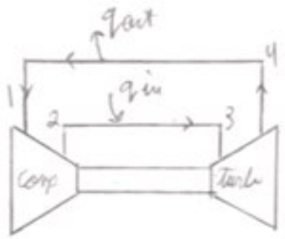


$$\eta_{Th} = 1 - \frac{T_1}{T_2} = 1 - \frac{1}{r^{\alpha}} \qquad \alpha = \frac{k-1}{k}$$

$$W_{out\,max} = C_p\left(\sqrt{T_3} - \sqrt{T_1}\right)^2$$ * use as check when $\eta = 1$

$$W_{out} = h_3 - h_4 \qquad W_{in} = h_1 - h_2 \qquad \eta_{T_{TH}} = \frac{h_{4a} - h_3}{h_{4s} - h_3}$$

$$W_{out} = \eta_T(T_3 - T_{4,s} \qquad \eta_c W_{act} = (T_{2,s} - T_1) \qquad \eta_{c_{TH}} = \frac{h_{2s} - h_1}{h_{2a} - h_1}$$

$$\left.\frac{T_4}{T_3}\right)_s = r_p^{\alpha} \qquad W_{act} = \frac{1}{\eta_c}(T_{2,s} - T_1)$$

$$T_{4,s} = T_3\, r_p^{\alpha} \qquad \left.\frac{T_2}{T_1}\right)_s = r_p^{\alpha}$$

$$W_{out} = \eta_T T_3(1 - r_p^{\alpha}) \qquad W_{in} = \frac{T_1}{\eta_c}(r_p^{\alpha} - 1$$

$$\boxed{W_{net} = \frac{T_1}{\eta_c}(r_p^{\alpha} - 1) - \eta_T T_3(1 - r_p^{\alpha})}$$

$$\eta_{II} = \frac{\eta_{Th\,Brayton}}{\eta_{th\,carnot}} = \frac{1 - \frac{q_{out}}{q_{in}}}{1 - \frac{T_L}{T_H}} = \frac{1 - r_p^{-\alpha}}{1 - \frac{T_0 \ln(T_2 T_3)}{T_2 + T_3}} = \boxed{\frac{(T_2 + T_3)(1 - r_p^{-\alpha})}{(T_2 + T_3) - T_0 \ln(T_2 T_3)}}$$

$$S_{gen} = \frac{q_{in}}{T_H} - \frac{q_{out}}{T_L} \qquad \phi_{\alpha} = T_0 S_{gen} \qquad T_0 = 25^\circ C$$

$$S_{gen,T} = -\frac{q_{in}}{T_3} + \frac{q_{out}}{T_{4,s}}$$

$$S_{gen,T} = -\frac{q_{in}}{T_3} + \frac{c_p(T_3 - T_{4a}) - \eta_{T_{TH}} T_3(1 - r_p^{\alpha})}{T_{4,a}}$$

$$= -\frac{q_{in}}{T_3} + \frac{c_p(T_3 - T_3 + \eta_{T_{TH}}(T_3 - T_{4s})) - \eta_{T_{TH}} T_3(1 - r_p^{\alpha})}{T_3 - \eta_{T_{TH}} T_3(1 - r_p^{\alpha})}$$

$$= -\frac{q_{in}}{T_3} + \frac{c_p \eta_{T_{TH}} T_3(1 - r_p^{\alpha}) - \eta_{T_{TH}}(1 - r_p^{\alpha})}{T_3 - \eta_{T_{TH}} T_3(1 - r_p^{\alpha})}$$

$$= -\frac{q_{in}}{T_3} + \frac{\eta_{T_{TH}} T_3(1 - r_p^{\alpha})(c_p - 1)}{T_3 - \eta_{T_{TH}} T_3(1 - r_p^{\alpha})}$$

$$S_{gen,T} = -\frac{q_{in}}{T_3} + \frac{\eta_{T_{TH}}(1 - r_p^{\alpha})(c_p - 1)}{1 - \eta_{T_{TH}}(1 - r_p^{\alpha})}$$

1st Law turb

$$\dot{m} h_3 - \dot{m} h_4 - \dot{Q}_{out} - \dot{W}_{out} = 0$$

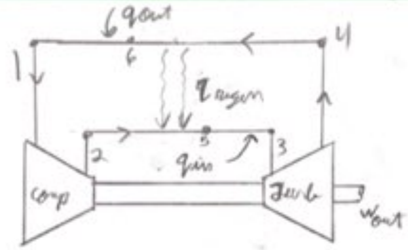
$$h_3 - h_4 - w_{out} = q_{out}$$

$$h_3 - h_4 - \eta_T T_3(1 - r_p^{\alpha}) = q_{out}$$

$$\eta_{T_{TH}} = \frac{\cancel{c_p}(T_3 - T_{4,a})}{\cancel{c_p}(T_3 - T_{4,s})}$$

$$T_3 - \eta_{T_{TH}}(T_3 - T_{4,s}) = T_{4,a}$$

Thermo II Project I | Brayton Cycle w/ Regenerator | 1/



$$\frac{d}{dr_p} W_{out,net} = C_p(T_3+T_1) - C_p T_3 \left(r_p^{-\alpha} + r_p^{-\alpha} \frac{T_1}{T_3}\right)$$

$$0 = 0 + \alpha c_p T_3 r_p^{\alpha-1} - \alpha c_p T_3 \frac{T_1}{T_3} r_p^{\alpha-1}$$

$$0 = \alpha c_p \left(T_3 r_p^{-\alpha-1} - T_1 r_p^{\alpha-1}\right)$$

$$T_1 r_p^{\alpha-1} = T_3 r_p^{-\alpha-1}$$

$$\frac{r_p^{\alpha-1}}{r_p^{-\alpha-1}} = \frac{T_3}{T_1}$$

$$r_p^{2\alpha} = \frac{T_3}{T_1}$$

$$r_p^* = \left(\frac{T_3}{T_1}\right)^{\frac{1}{2\alpha}}$$

$$W_{out,net\,max} = c_p\left(T_3+T_1-2\sqrt{T_1 T_3}\right)$$

$$\boxed{W_{out,net\,max} = c_p\left(\sqrt{T_3}+\sqrt{T_1}\right)^2}$$

$$W_{out,net} = 2c_p\left[T_{max}(1 - r_{p,1}^{-\alpha}) - T_{min}(r_{p,1}^{\alpha} - 1)\right] \quad ; \quad r_{p1} = \sqrt{r_p}$$

$$= 2c_p\left[T_{max}(1 - r_p^{-\frac{1}{2}\alpha}) - T_{min}(r_p^{\frac{\alpha}{2}} - 1)\right]$$

$$\frac{dW}{dr_p} = \cancel{2}c_p\, T_{max}\left(\tfrac{1}{\cancel{2}}\cancel{\alpha}\, r_p^{-\frac{\alpha}{2}-1}\right) - \cancel{2}c_p T_{min}\left(\tfrac{\cancel{\alpha}}{\cancel{2}}\, r_p^{\frac{\alpha}{2}-1}\right) = 0$$

$$0 = T_{max}\, r_p^{-\frac{\alpha}{2}-1} - T_{min}\, r_p^{\frac{\alpha}{2}-1}$$

$$\frac{r_p^{\frac{1}{2}\alpha - 1}}{r_p^{-\frac{1}{2}\alpha - 1}} = \frac{T_{max}}{T_{min}}$$

$$r_p^{\alpha} = \frac{T_{max}}{T_{min}}$$

$$r_p^{*} = \left(\frac{T_{max}}{T_{min}}\right)^{\frac{1}{\alpha}} \qquad r_{p,1} = \left(\frac{T_{max}}{T_{min}}\right)^{\frac{1}{2\alpha}}$$

$$W_{out,net,max} = 2c_p\left[T_{max}\left(1 - \left(\frac{T_{max}}{T_{min}}\right)^{-\frac{1}{2}}\right) - T_{min}\left(\left(\frac{T_{max}}{T_{min}}\right)^{1/2} - 1\right)\right]$$

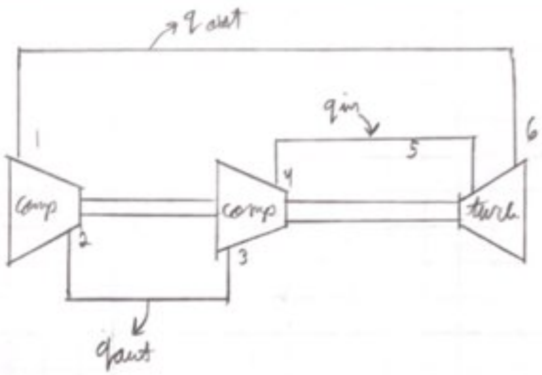
$$= 2c_p\left[T_{max} - \sqrt{T_{min}T_{max}}\right] - 2c_p\left[\sqrt{T_{min}T_{max}} - T_{min}\right]$$

$$= 2c_p\left[T_{max} - \sqrt{T_{min}T_{max}} - \sqrt{T_{min}T_{max}} + T_{min}\right]$$

$$= 2c_p\left[T_{max} - 2\sqrt{T_{min}T_{max}} + T_{min}\right]$$

$$\boxed{W_{out,net,max} = 2c_p\left[\sqrt{T_{max}} - \sqrt{T_{min}}\right]^2}$$

Thermo II Project I | Brayton Cycle w/ Intercooling | 1/



$\dot{m} h_1 + \dot{W}_{in} - \dot{m} h_2 = 0$ $\qquad$ $\dot{m} h_5 - \dot{m} h_6 - \dot{W}_{out} = 0$

$w_{in} = h_2 - h_1$

$w_{in} = h_4 - h_3$

$w_{out} = h_6 - h_5$

$w_{out,net} = (h_6 - h_5) - \left[(h_2 - h_1) + (h_4 - h_3)\right]$

$T_5 = T_{max}$

$T_1 = T_{min}$

$T_1 = T_3$

$T_4 = T_2$

$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\alpha}$

$T_2 = T_1 r_{P,1}^{\alpha}$

$\frac{T_6}{T_5} = \frac{P_6}{P_5}^{\alpha} = r_P^{-\alpha}$

$T_6 = T_5 r_P^{-\alpha}$

$$w_{out,net} = \eta_{T,s} c_p (T_6 - T_5) - \eta_{C,s} c_p (T_2 + T_4 - T_1 - T_3)$$

$$= \eta_{T,s} c_p (T_6 - T_5) - \eta_{C,s} c_p (2T_2 - 2T_1)$$

$$= \eta_{T,s} c_p T_{max} (r_P^{-\alpha} - 1) - 2 \eta_{C,s} T_{min} c_p (r_{P,1}^{\alpha} - 1)$$

$$= c_p \left(\eta_{T,s} T_{max} (r_P^{-\alpha} - 1) + 2 \eta_{C,s} T_{min} (1 - r_{P,1}^{\alpha}) \right)$$