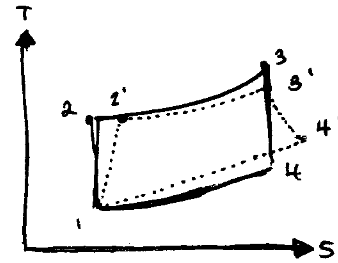
Oct. 30/18



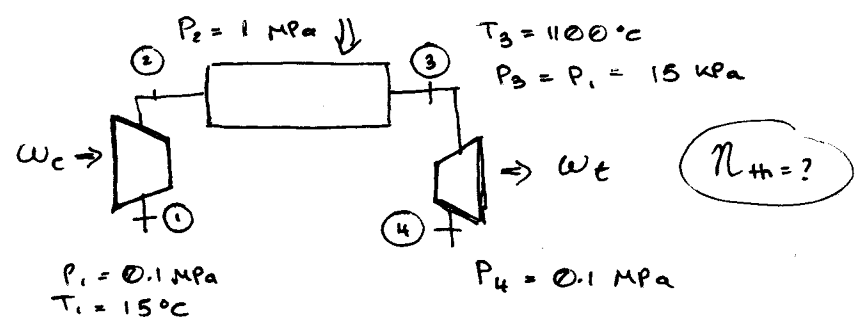
back work $= \dfrac{w_c}{w_t}$

In Bryton Cycle, the compressor might require 40 to 80 % of the output of the Turbine.

In Rankine Cycle, 1 or 2 % of the turbine work is required to drive the pump.

(10.2)

$\boxed{\text{Example}}$



$w_{ca} = h_2 - h_1$

(isentropic)

$$\eta_c = \frac{w_{cs}}{w_{ca}} = \frac{h_{2s} - h_1}{h_{2a} - h_1} = \frac{\cancel{c_p}(T_{2s} - T_1)}{\cancel{c_p}(T_{2a} - T_1)} \qquad \text{I}$$

(actual)

$$\frac{T_{2s}}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} \Rightarrow T_{2s} = (15 + 273.2)\left(\frac{1}{0.1}\right)^{\frac{0.4}{1.4}}$$

$$\longrightarrow \boxed{T_{2s} = 556.8 \text{ K}}$$

From I: $0.8 = \dfrac{556.8 - 288.2}{T_{2a} - 288.2} \longrightarrow \boxed{T_{2a} = 624 \text{ K}}$

$w_{ca} = c_p(T_{2a} - T_1) = (1.004)(624 - 288.2) = 337$ kJ/kg

$w_{ta} = h_3 - h_{4a} = c_p(T_3 - T_{4a})$

$$\eta_T = \frac{w_{Ta}}{w_{Ts}} = \frac{h_3 - h_{4a}}{h_3 - h_{4s}} = \frac{\cancel{c_p}(T_3 - T_{4a})}{\cancel{c_p}(T_3 - T_{4s})} \qquad \text{II}$$

$$\frac{T_3}{T_{4s}} = \left(\frac{P_3}{P_4}\right)^{\frac{k-1}{k}} \rightarrow \boxed{T_{4s} = 713.9 \text{ K}}$$

From II: $0.85 = \dfrac{1373 - T_{4a}}{1373 - 713.9} \rightarrow \boxed{T_{4a} = 812.8 \text{ K}}$

$w_{Ta} = c_p(T_3 - T_{4a}) = 1.004(1373.2 - 812.8)$

$w_{Ta} = 562.4$ kJ/kg

7) (continued)

$$w_{net} = w_{Ta} - w_{ca} = 562.4 - 337 = 225.4$$

$$r_{BW} = \frac{w_{ca}}{w_{Ta}} = \frac{337}{568.4} = 0.6 \rightarrow 60\%$$

$$\eta_{th} = \frac{w_{net}}{q_h} = \frac{225.4}{\cdots}$$

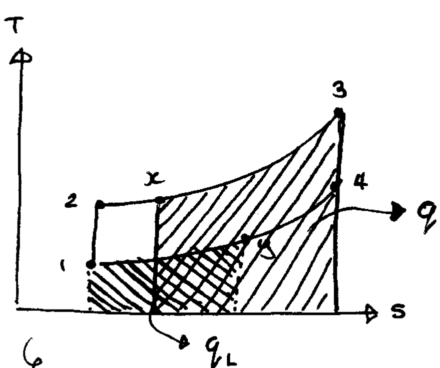
$$q_h = h_3 - h_{2a} = C_p(T_3 - T_{2a}) = (1.004)(1373.2 - 624)$$
$$= 751.8 \text{ kJ/kg}$$

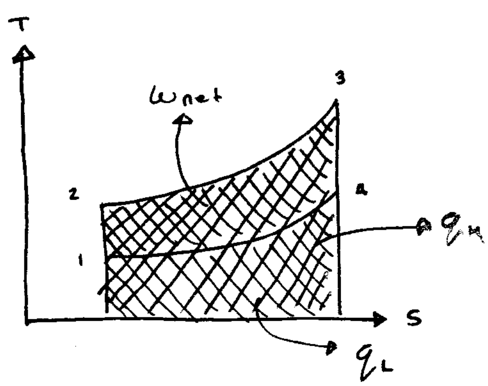
$$\eta_{th} = \frac{w_{net}}{q_{hs}} = \frac{w_{Ts} - w_{cs}}{q_{hs}} = \frac{C_p(T_3 - T_{4s}) - C_p(T_{2s} - T_1)}{C_p(T_3 - T_{2s})}$$

$$\eta_{ths} = \frac{T_3 - T_{4s} - T_{2s} + T_1}{T_3 - T_{2s}} = \frac{1373.2 - 713.9 - 556.8 + 288.2}{1373.2 - 556.8}$$

$$\eta_{ths} \cong 48\%$$

/end





with refrigeration

the efficiency of this cycle w/ regeneration

$$\eta_{th} = w_{net}/q_H = \frac{w_t - w_c}{q_H}$$

$$q_H \cong C_p(T_3 - T_x)$$

$$w_t \cong C_p(T_3 - T_4)$$

For an ideal regenerator, $T_4 = T_x$, $\therefore q_H = w_t$

$$\rightarrow \eta_{th} = 1 - \frac{T_1}{T_3}\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} = 1 - \frac{T_2}{T_3}$$

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1	10 kPa Sat. liq.	$\Rightarrow h_1 = 191.8\ \frac{kJ}{kg}$	
2	0.5 MPa	$\Rightarrow h_2 = 192.3\ \frac{kJ}{kg}$	
3	0.5 MPa Sat. liq.	$\Rightarrow h_3 = 640.09\ \frac{kJ}{kg}$	
4	15 MPa	$\Rightarrow h_4 = 643.92\ \frac{kJ}{kg}$	
5	15 MPa		
6	4 MPa Sat. liq.	$\Rightarrow h_6 = 1087.4\ \frac{kJ}{kg}$	
7	15 MPa	$\Rightarrow h_7 = 1101.2$ kJ/kg	
8	15 MPa		
9	15 MPa 600 °C	$\Rightarrow h_9 = 3582$ kJ/kg	
10	4 MPa	$\Rightarrow h_{10} = 3155$ kJ/kg	
11	4 MPa 600 °C	$\Rightarrow h_{11} = 3674.9$ kJ/kg	
12	0.5 MPa	$\Rightarrow h_{12} = 3014.8$ kJ/kg	
13	10 kPa	$\Rightarrow h_{13} = 2337.7$ kJ/kg	

$S_9 = S_{10}$, $S_{11} = S_{12} = S_{13}$

$\dot{m}_{11} = (1-y)\,\dot{m}_{10}$

$\dot{m}_6 = y\,\dot{m}_{10}$

$\dot{m}_{11}/\dot{m}_{12} = 1-y/z$

→ $v_1 = 0.00101$

$w_{p_1} = v_1(P_2 - P_1)$

$\Rightarrow (0.00101)(500-10) = 0.4949$

$w_p = h_2 - h_1 \longrightarrow h_1 = 192.3$ kJ/kg

→ $w_{p2} = h_4 - h_3 \rightsquigarrow w_{p2} = v_3(P_4 - P_3)$

→ $w_{p3} = h_7 - h_6 \rightsquigarrow w_{p3} = v_6(P_7 - P_6)$

→ $S_{10} = S_9 = 6.6775$ (superheated) (interpolate)

→ $S_{12} = S_{11} = 7.3688$ (interpolate)

→ $S_{13} = S_{12} = S_{11} = 7.3688$ $\quad h_f = 191.8$, $h_{fg} = 2392.82$ $\Big\}$ $S_f = 0.6492$, $S_{fg} = 7.5010$

$S_{13} = S_f + x_{13} S_{fg}$

$7.5010 = 0.6492 + x_{13}(7.5010)$

$h_{13} = h_f + x_{13} h_{fg}$

$h_{13} = 191.81 + (0.8958)(2392.82)$

$h_{13} = 2335.7$ kJ/kg

C. FWH:

$$y h_{10} + (1-y) h_9 = (1-y) h_5 + y h_6$$

mixer:

$$h_8 = (1-y) h_5 + y h_7 \qquad \text{II}$$

For ideal CFWH $\Rightarrow$ $h_6 = h_5 = 1087.4 \text{ kJ/kg}$

From I and II : $y = 0.1766$

$h_8 = 1089.8$

O. FWH:

$$z h_{12} + (1-y-z) h_2 = (1-y) h_3$$

$z = 0.1306$

10.3

Example

$q_H = h_3 - h_x$

$T_4 = T_x = ?$

$T_4 / T_3 = (P_4/P_3)^{\frac{k-1}{k}} \Rightarrow T_4 = 710.8\ K$

1373.2

$q_H = C_p (T_3 - T_x) = 1.004 (1373.2 - 710.8)$

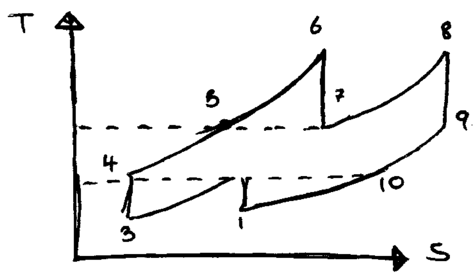
$q_H = 664.7\ kJ/kg$

From previous example:

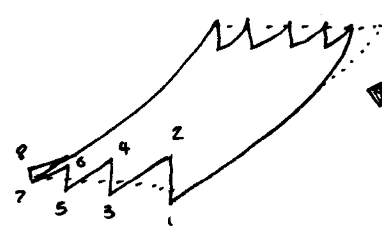
$w_{net} = 395.2\ kJ/kg \longrightarrow \eta_{th} = \dfrac{395.2}{664.7} = 59.5\ \%$

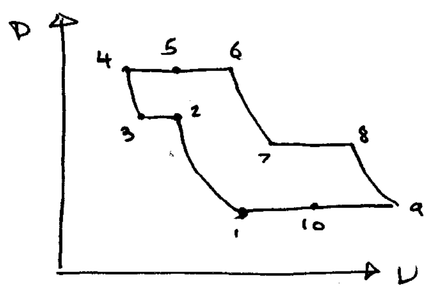
$\eta_{th,\ without\ ref.} = 48.2\ \%$

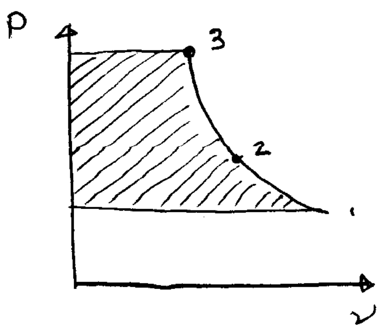
Gas turbine Power-Cycle Configuration

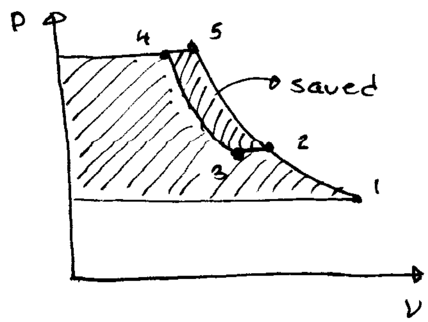


Ericson Cycle



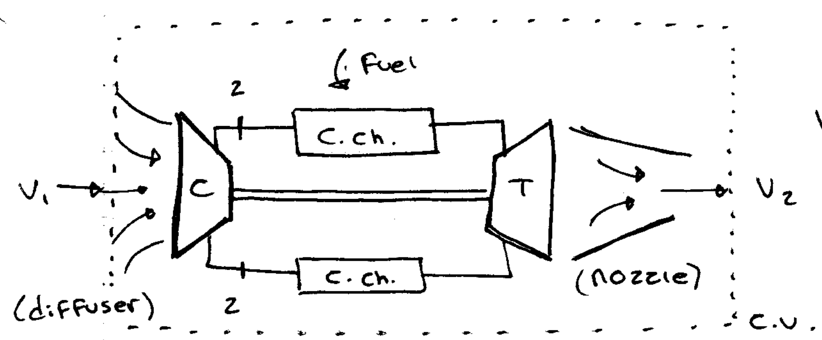






(with intercooler)

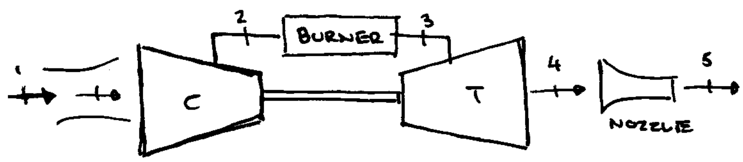
$w = -\int v\,dp$

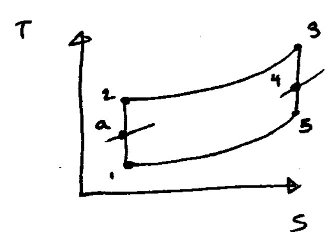


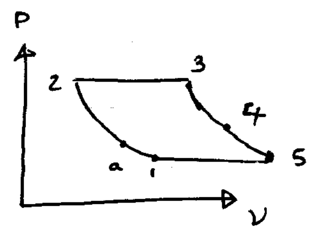
$V_2 \gg V_1$

(basically a turbo-jet)

Air-Standard Cycle For Jet Propulsion







$\boxed{\text{Example:}}$ "Consider an ideal jet propulsion cycle in which air enters the compressor at 0.1 MPa and 15°C ..."

↳ 10.5

$P_1 = 0.1\ \text{MPa}$ $\qquad T_1 = 288.2\ \text{K}$

$P_2 = 1\ \text{MPa}$ $\qquad T_2 = 556.8\ \text{K}$

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

$$w_c = C_p(T_2 - T_1) = (1.004)(556.8 - 288.2)$$
$$= \mathbf{269.5}\ \text{kJ/kg}$$

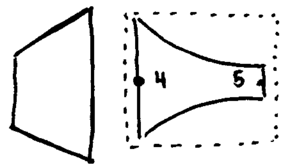
$P_3 = 1\ \text{MPa}$ $\qquad w_c = w_t = 269.5$

$T_3 = 1373.2\ \text{K}$

$$w_T = C_p(T_3 - T_4) \Rightarrow 269.5 = (1.004)(1373.2 - T_4)$$
$$T_4 = 1104.6\ \text{K}$$

$$\left(\frac{T_4}{T_3}\right) = \left(\frac{P_4}{P_3}\right)^{\frac{0.4}{1.4}} \Rightarrow P_4 = 0.4668\ \text{MPa}$$

6



$$\cancel{q} + h_4 + \cancel{V_4^2/2} + \cancel{gz_4} = \cancel{w} + h_5 + V_5^2/2 + \cancel{gz_5}$$

$$h_4 = h_5 + \frac{V_5^2}{2}$$

$$\frac{T_5}{T_4} = \left(\frac{P_5}{P_4}\right)^{\frac{k-1}{k}} \Rightarrow T_5 = 710.8 \text{ K}$$

$$V_5^2 = 2C_p(T_4 - T_5) = 2(1.004)(1104.6 - 710.8)$$

(x1000)

$$\rightarrow \boxed{V_5 = 889 \text{ m/s}}$$