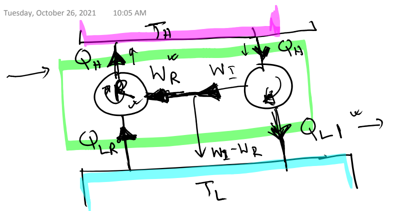
Tuesday, October 26, 2021 10:05 AM



Corr 1 → $W_R > W_I$

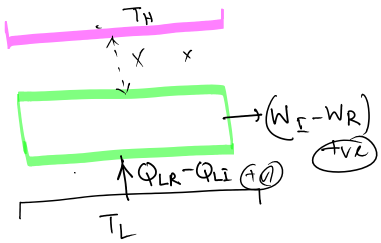
Corr 1 is WRONG!!

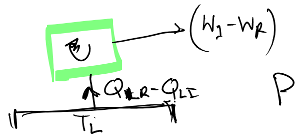
$W_I > W_R$

$Q_{LI} < Q_{LR}$

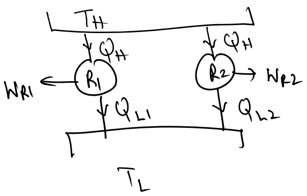
$Q_{L_I} = Q_H - W_I$

$Q_{L_R} = Q_H - W_R$





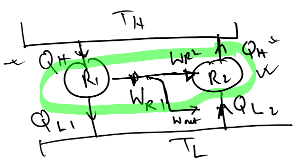
PMM II !!!



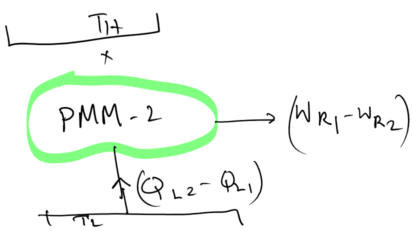
$W_{R1} = W_{R2}$

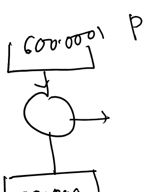
$\eta_{R1} = \eta_{R2}$ .... $\eta = f(T_H, T_L)$

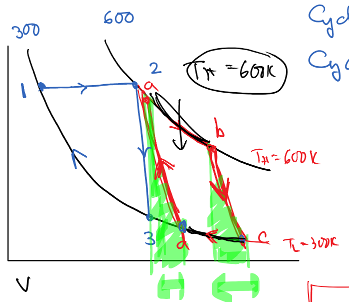
Let us assume $W_{R1} > W_{R2}$



$W_{net} = (W_{R1} - W_{R2})$







Cycle 1 → 1 → 2 → 3 → 1

Cycle 2 = Carnot cycle a → b → c → d → a [Frictionless, Highly quasistatic]

η_1 , η_2

Effn. of a Carnot Cycle

	Q	W	ΔU
a−b (ISOTh)	$RT_H \ln x$	$RT_H \ln x$	0
b−c	0	$R\Delta T/(1-\gamma)$	$-R\Delta T/(1-\gamma)$
c−d	$-RT_L \ln x$	$-RT_L \ln x$	0
d−a	0	$-R\Delta T/(1-\gamma)$	$+R\Delta T/(1-\gamma)$
	$R \ln x\,(T_H - T_L)$		0

$\Delta T = T_c - T_b$

$Q - W = \Delta U$

$p_a V_a^\gamma = p_d V_d^\gamma$

$p_b V_b^\gamma = p_c V_c^\gamma$

$$\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} = \left(\frac{V_1}{V_2}\right)^{n-1}$$

$$\frac{T_d}{T_a} = \left(\frac{V_a}{V_d}\right)^{\gamma-1} ; \quad \frac{T_b}{T_c} = \left(\frac{V_c}{V_b}\right)^{\gamma-1}$$

$$\frac{T_d}{T_a} = \left(\frac{V_a}{V_d}\right) \quad ; \quad \frac{T_b}{T_c} = \left(\frac{V_c}{V_b}\right)$$

$$\Rightarrow \frac{T_d}{T_a} = \frac{T_c}{T_b} \Rightarrow \left(\frac{V_a}{V_d}\right)^{\gamma-1} = \left(\frac{V_b}{V_c}\right)^{\gamma-1}$$

or $\frac{V_a}{V_d} = \frac{V_b}{V_c}$

or $\frac{V_a}{V_b} = \frac{V_d}{V_c} = \frac{1}{x}$

$V_b/V_a = x = V_c/V_d$

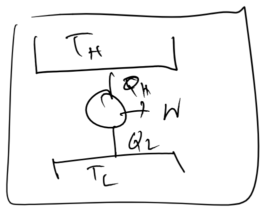
$$W = \frac{p_f v_f - p_i v_i}{1-n} = \frac{R(T_f - T_i)}{1-\gamma} = \frac{R\Delta T}{1-\gamma}$$

$$W_{net} = R(T_H - T_L)\ln x$$

$$Q_H = RT_H \ln x$$

$$\eta = \frac{W_{net}}{Q_H} = \frac{T_H - T_L}{T_H} = 1 - \frac{T_L}{T_H}$$

$$\eta = f(T_H, T_L)$$

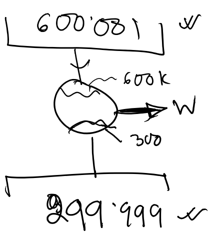


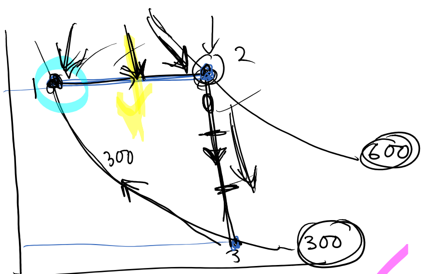
Irreversible

Monatomic $\gamma = 1.67$

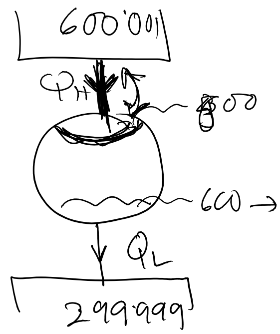
Diatomic $\gamma = 1.4$

Triatomic $\gamma = 1.28$





$$\frac{v_3}{v_1} = \frac{v_3}{v_2} \times \frac{v_2}{v_1} = 1 \times 2$$



$$W_{12} = p_2 v_2 - p_1 v_1 = R\Delta T$$

$$\Delta U_{12} = C_v \Delta T = \frac{R}{\gamma - 1}\Delta T$$

$$Q_{12} = R\Delta T\left[1 + \frac{1}{\gamma-1}\right] = R\Delta T \frac{\gamma}{\gamma-1}$$

$$\Delta U_{23} = -C_v \Delta T$$

	Q	W	ΔU
1–2	$R\Delta T \frac{\gamma}{\gamma-1}$	$R\Delta T$	$\frac{R}{\gamma-1}\Delta T$
2–3	$-\frac{R}{\gamma-1}\Delta T$	0	$-\frac{R}{\gamma-1}\Delta T$
3–1	$-RT_L \ln 2$	$-RT_L \ln 2$	0
	$R\Delta T - RT_L \ln 2$	$R\Delta T - RT_L \ln 2$	0
	$\oint dQ$	$\oint dW$	

I

3–1 Q_{Reject} is Rev

2–3

$$W = (R\Delta T - RT_L \ln 2)$$

$$Q_H = R\Delta T$$

$$\eta = \frac{R\Delta T - RT_L \ln 2}{R\Delta T \times \left(\frac{\gamma}{\gamma-1}\right)} = \left[1 - \left(\frac{T_L}{\Delta T}\right)\ln 2\right] \times \left(\frac{\gamma-1}{\gamma}\right)$$

I ⇒ Heat Addition or removal under FINITE temperature difference

External Irrever

For our case

$T_L = 300$

$\Delta T = T_H - T_L = 300$

$$\eta = (1 - \ln 2)\left(\frac{\gamma-1}{\gamma}\right)$$

$\Delta T = T_H - T_L = 300$

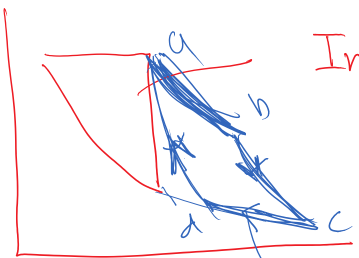
He: $\gamma = 1.67$, $\eta = 12.3\%$

$\gamma = 1.4$, $\eta = 8.7\%$

$\eta_{Carnot} = 50\%$

External Irreversibility

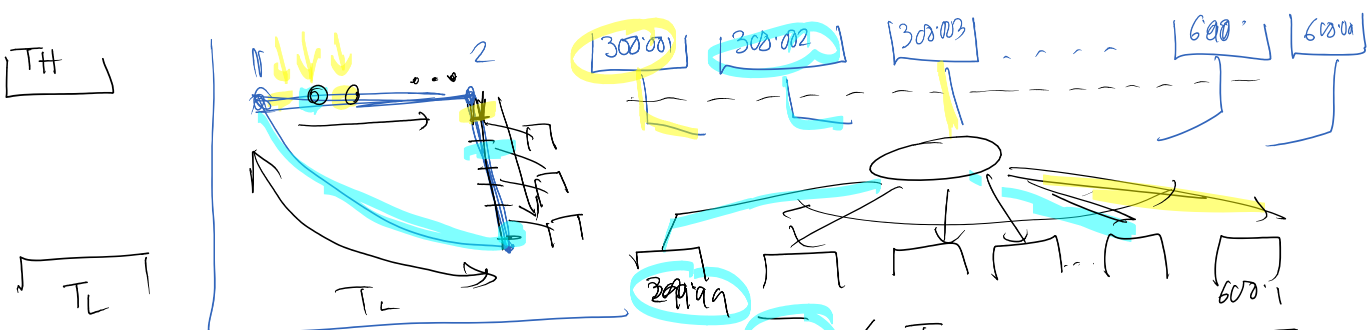
$$\eta = f(T_H, T_L, \gamma)$$



Internally reversible, but externally irreversible if we are using two fixed-temperature thermal reservoirs

Carnot cycle was both Internally & externally reversible

Adiabatic & isothermal processes can be suitable candidates for total reversible processes



$\overline{T_H} < T_H$

& $\overline{T_L} > T_L$

$$\eta_{Real} = 1 - \frac{\overline{T_L}}{\overline{T_H}}$$

$$\boxed{\eta_{Real} < \eta_{Carnot}}$$

$$\eta_{carnot} = 1 - \frac{T_L}{T_H}$$

$$\eta_{any\ Rev} = 1 - \frac{T_L}{T_H}$$

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