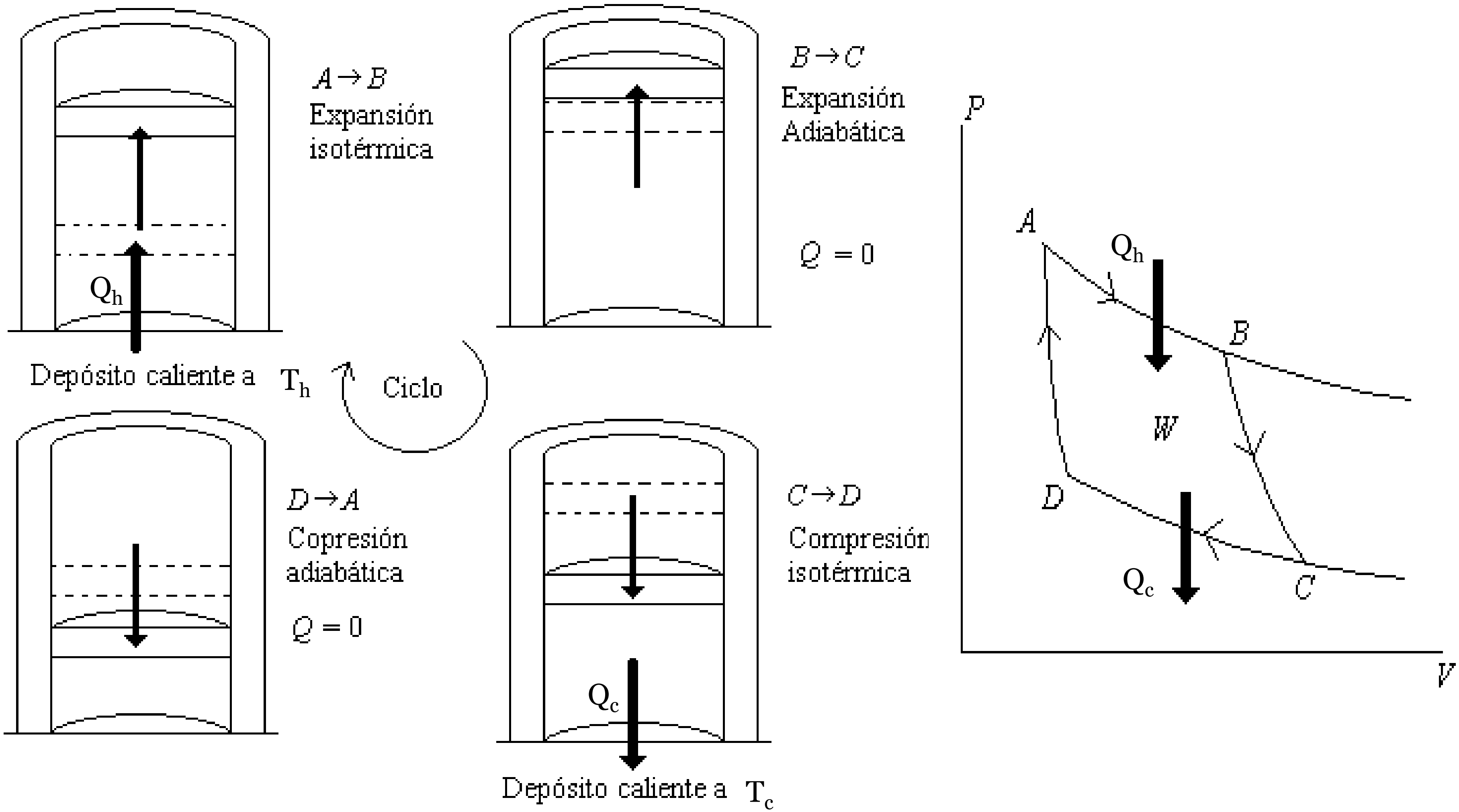
SEGUNDA LEY DE LA TERMODINÁMICA

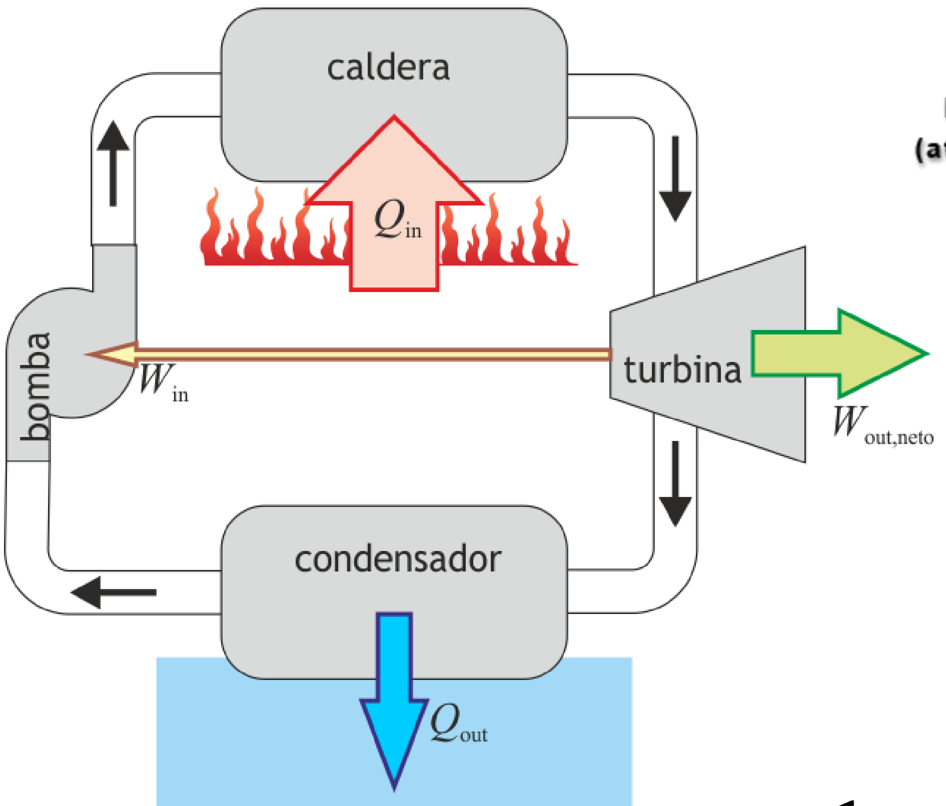
Unidad 3

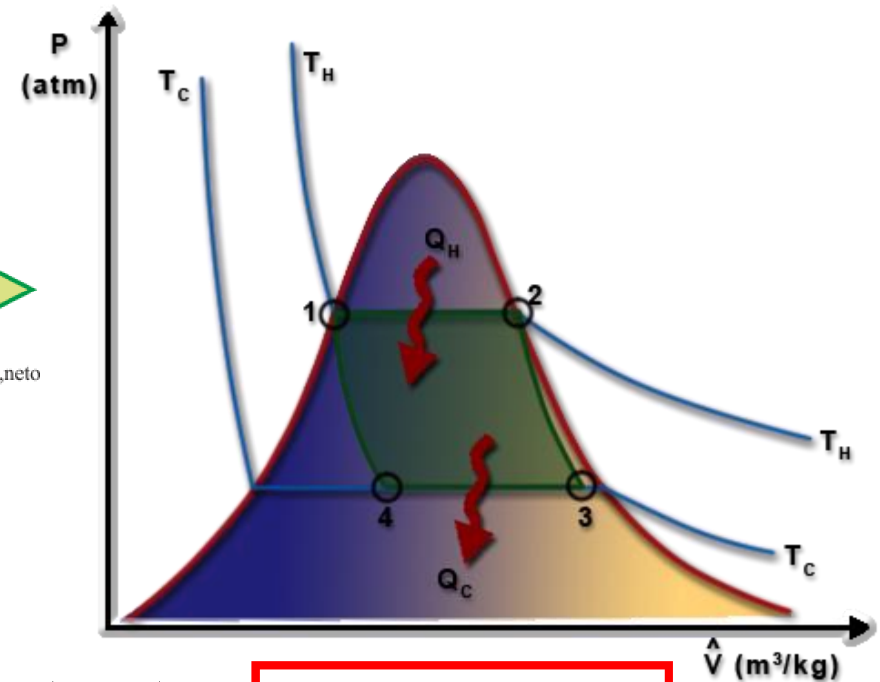
La máquina de Carnot (utilizando un gas ideal)

El ciclo de Carnot



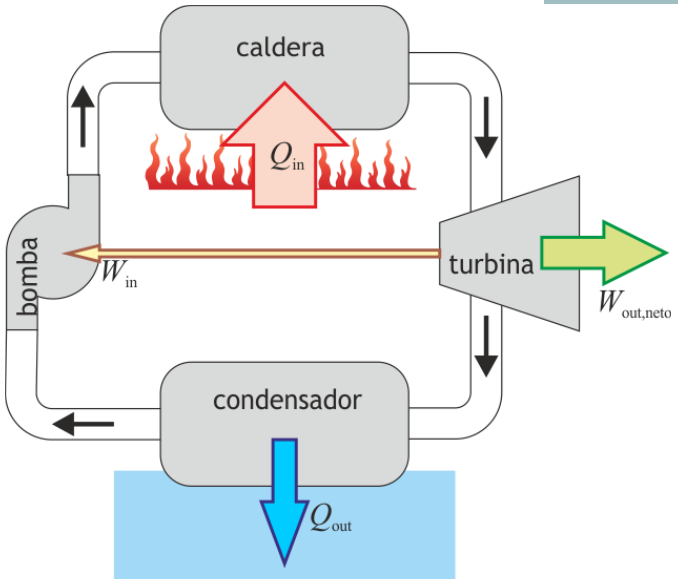
Ciclo de Carnot con un fluido real y en funcionamiento continuo

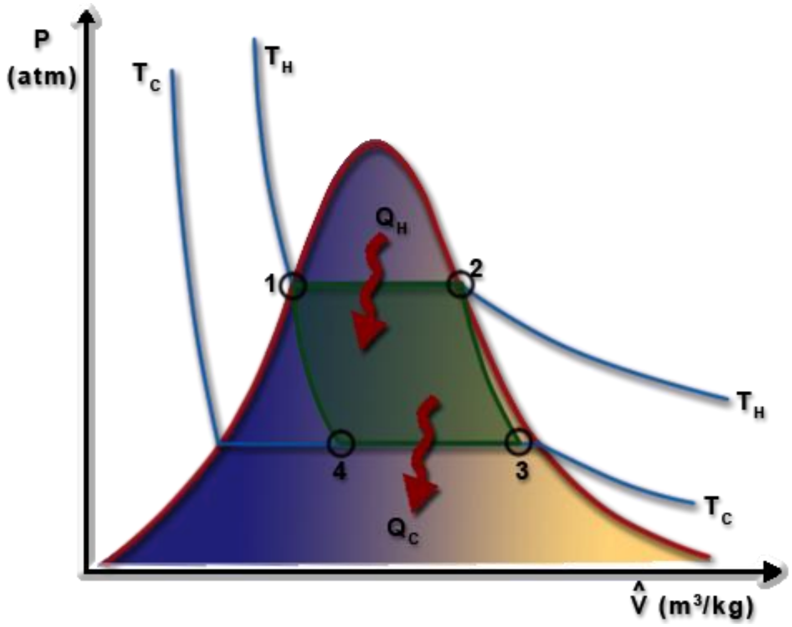


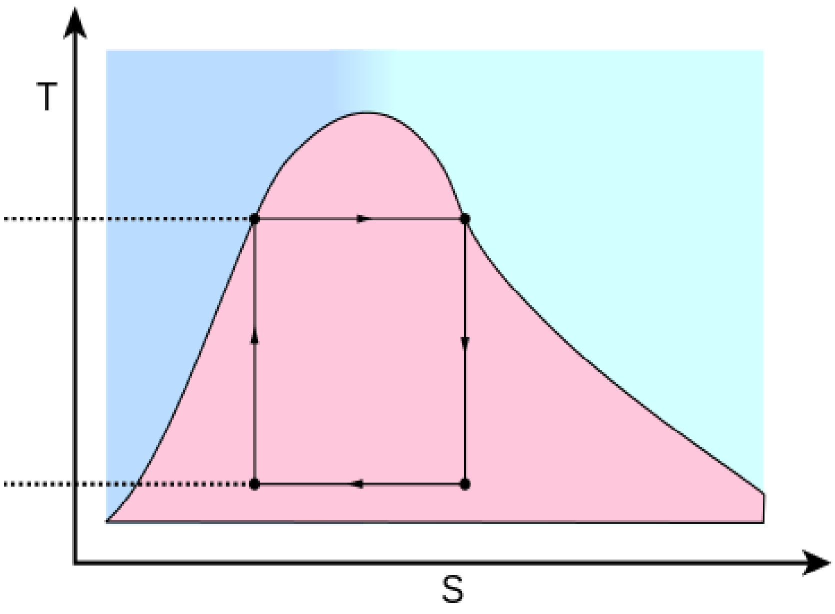


$$\eta \equiv 1 - \frac{|Q_C|}{|Q_H|}$$

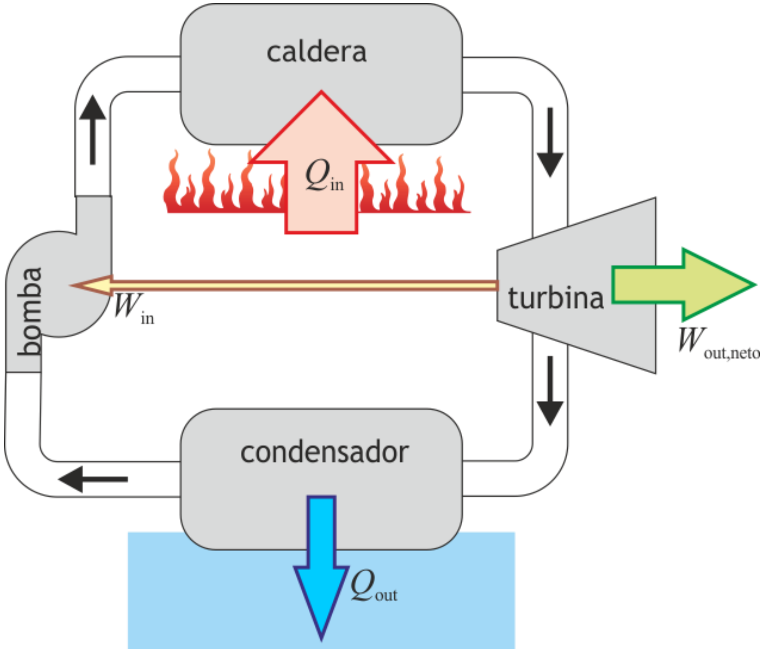
$$\eta \equiv 1 - \frac{T_C}{T_H}$$

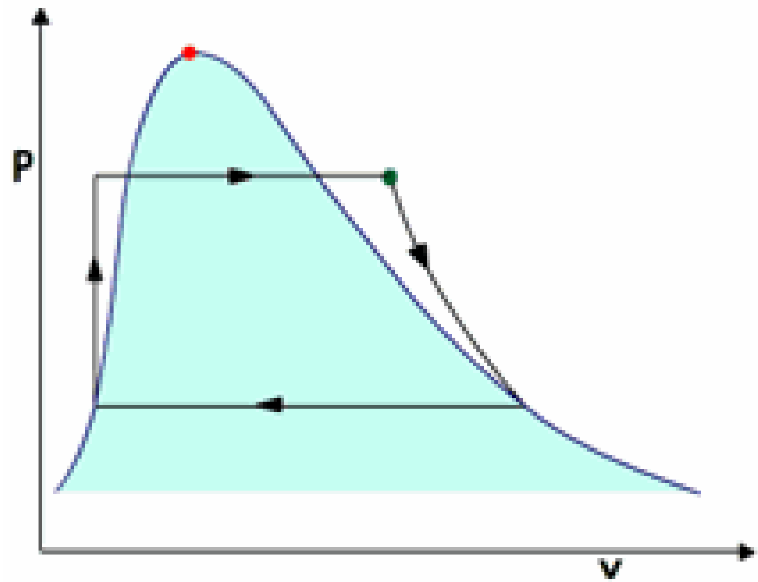

caldera
Q_{in}
bomba
W_{in}
turbina
$W_{out,neto}$
condensador
Q_{out}

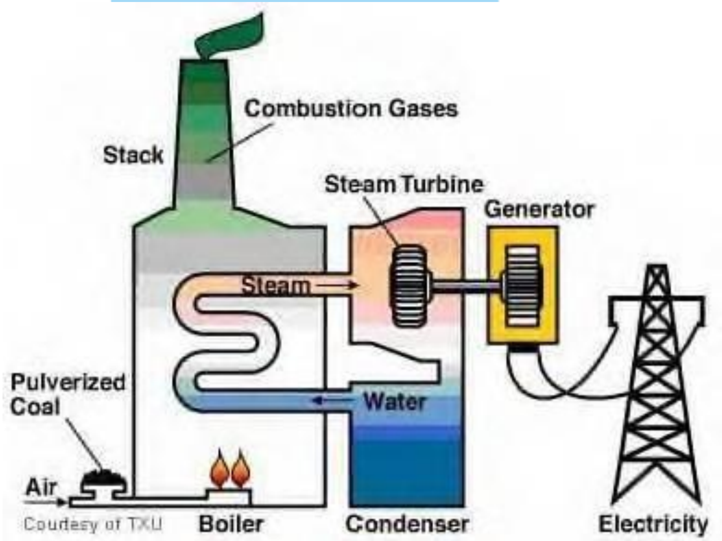

P
(atm)
T_C
T_H
Q_H
1
2
T_H
4
3
T_C
Q_C
$\hat{V}$ (m³/kg)

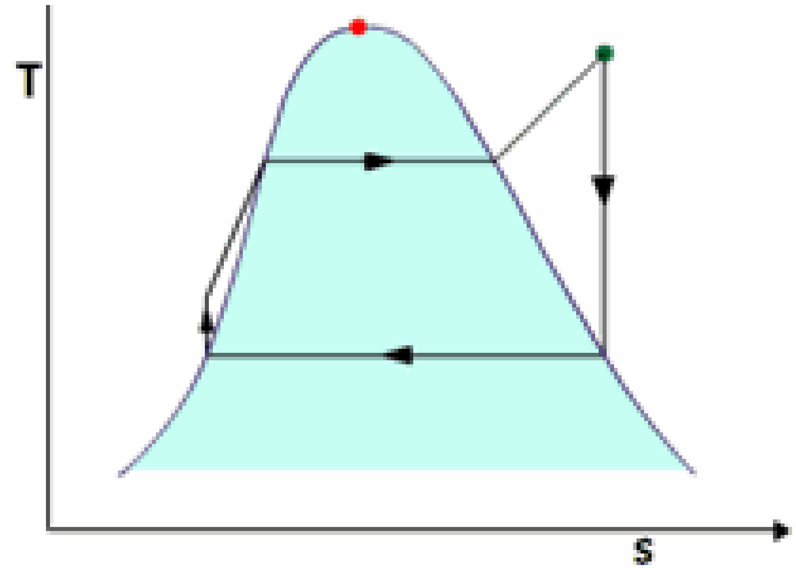

T
S

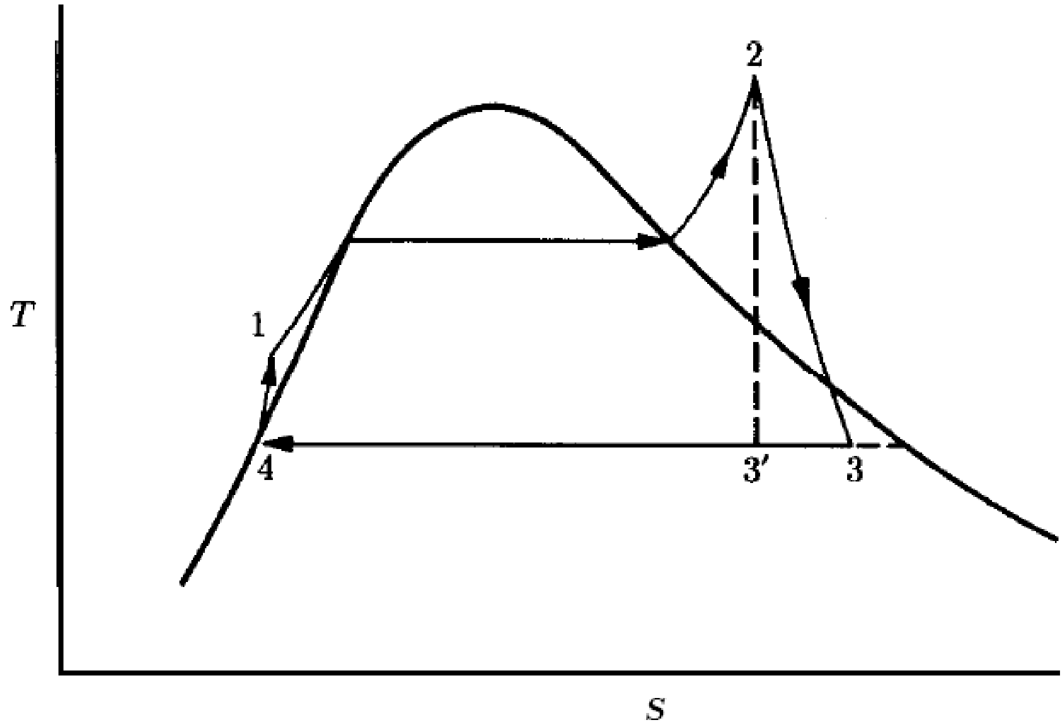
Ciclo Rankine



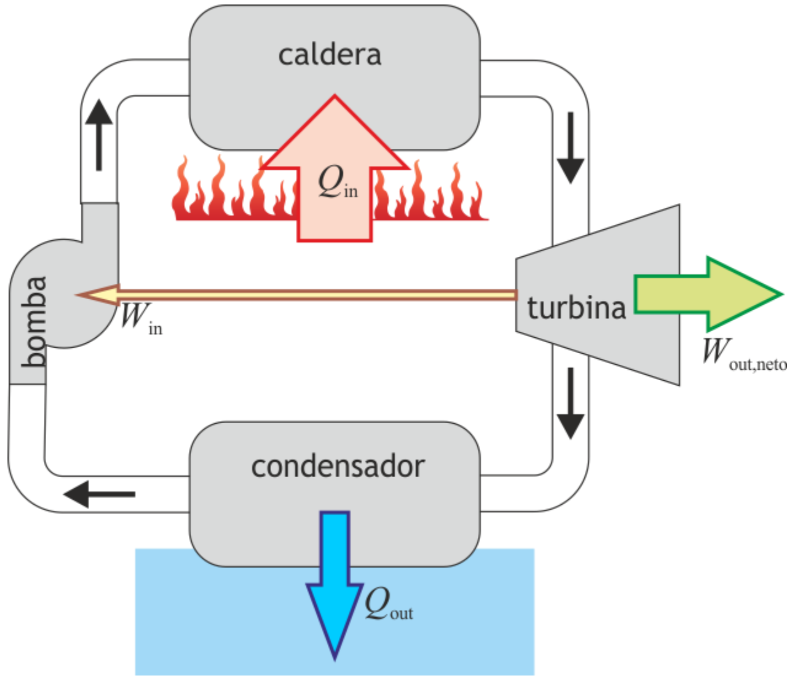








Ciclo práctico simple de energía



$$\eta \equiv \frac{|W|}{|Q_H|} = 1 - \frac{|Q_C|}{|Q_H|}$$

$$|W| = |W_{turbina} + W_{bomba}|$$

$$|W| = |W_{turbina}| - |W_{bomba}|$$

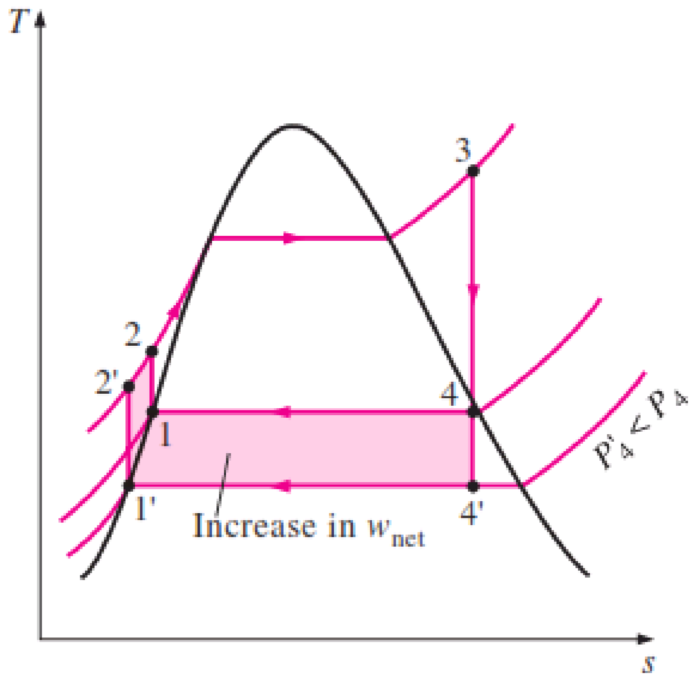
$$W_{turbina} = \Delta H_{turbina}$$

$$W_{bomba} = \Delta H_{bomba}$$

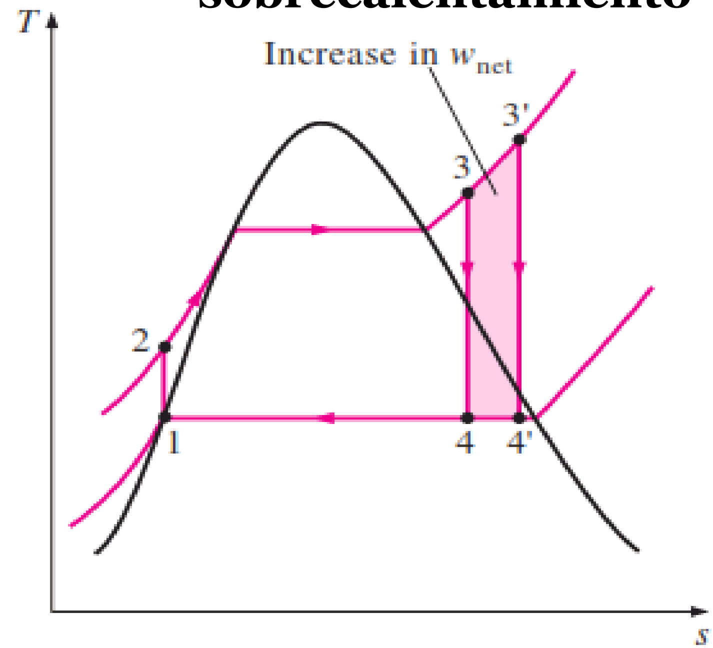
$$Q_C = \Delta H_{condensador}$$

$$Q_H = \Delta H_{caldera}$$

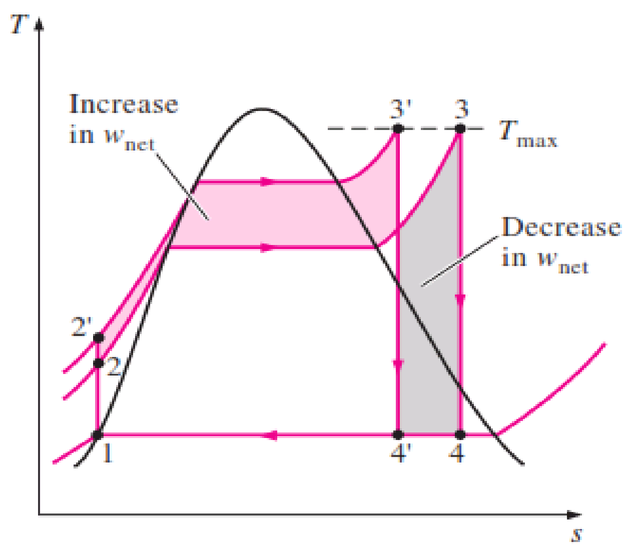
Reducir la P del condensador

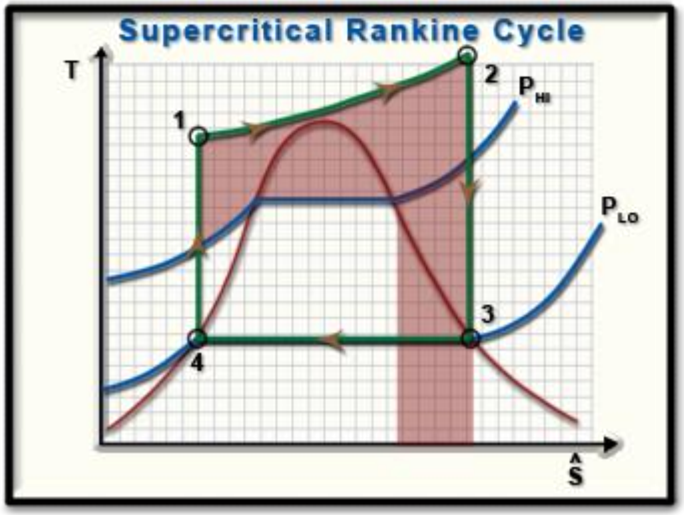


Aumentar la T de sobrecalentamiento



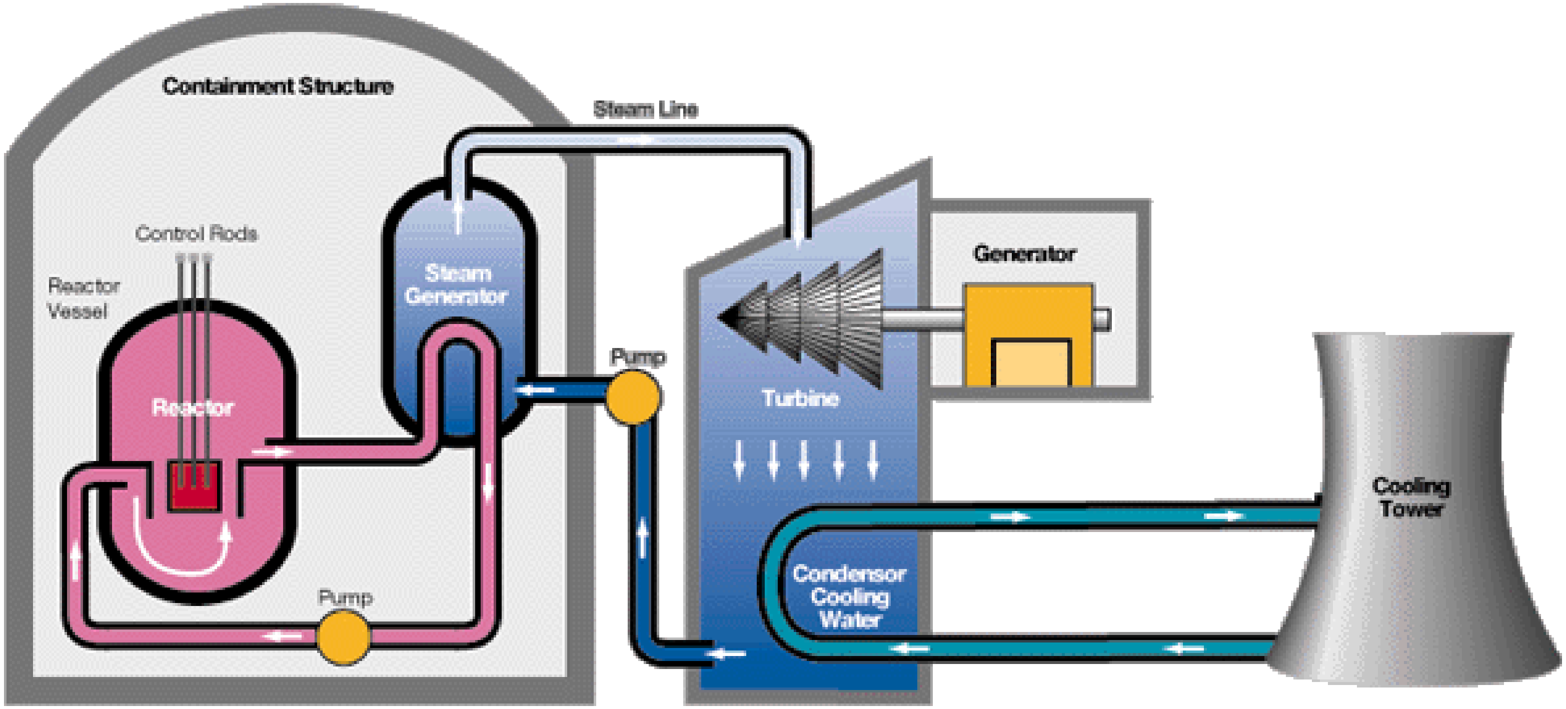
Aumentar la P de la caldera

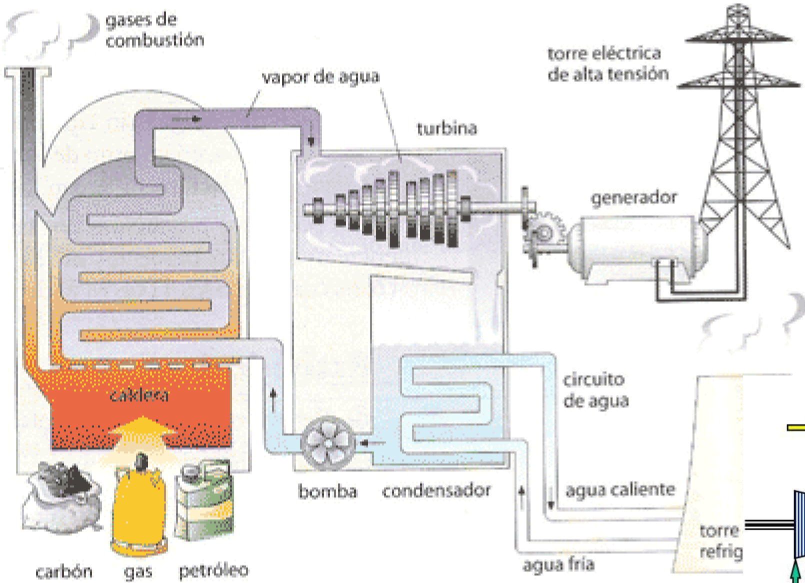




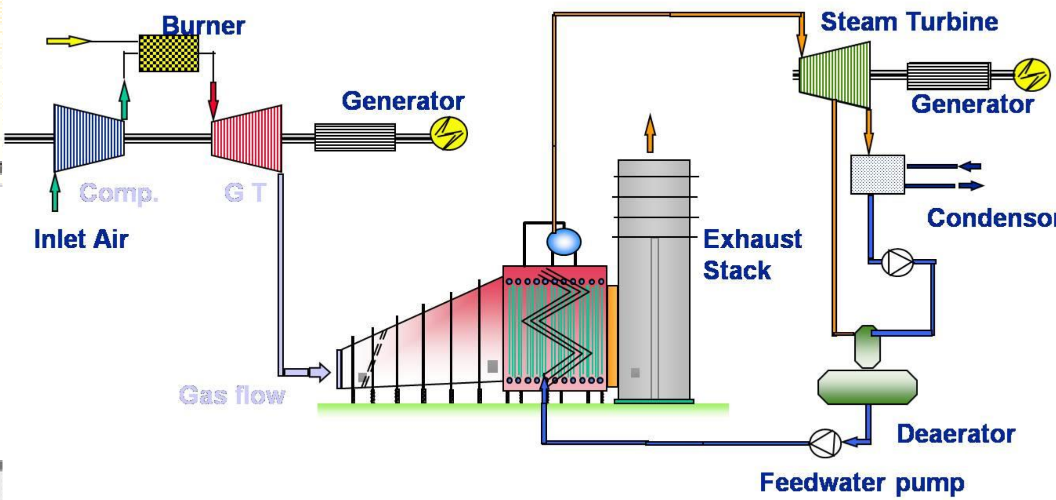
http://www.encuentro.gov.ar/sitios/encuentro/programas/ver?rec_id=50109

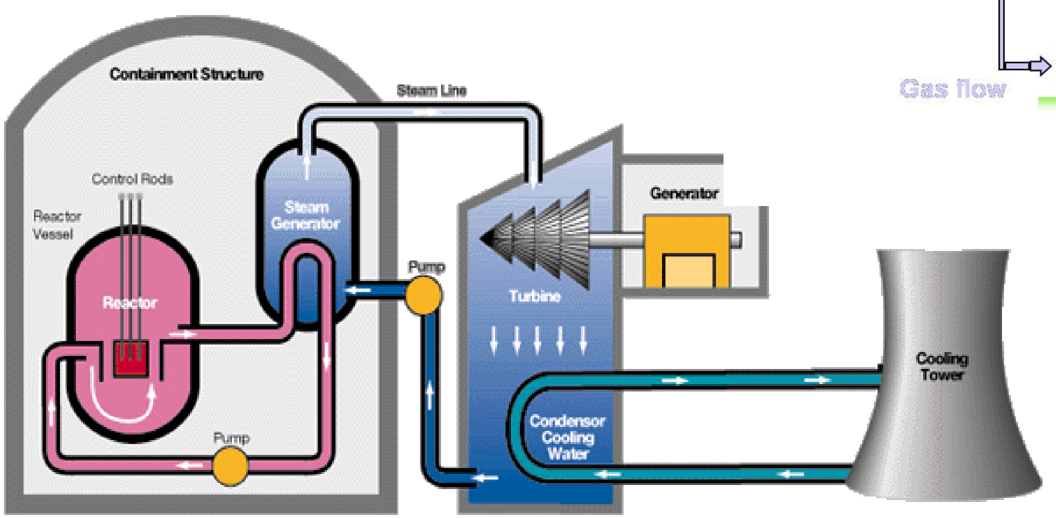
Energía nuclear

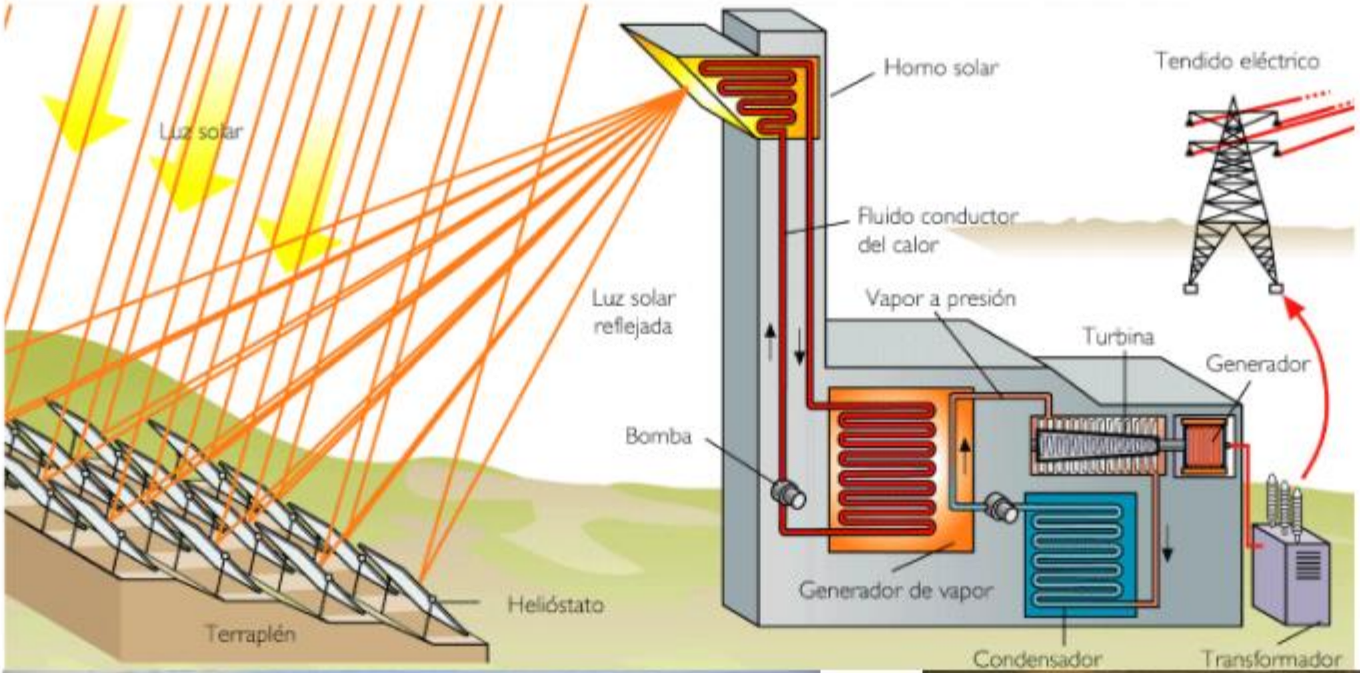




Esquema de una central térmica.

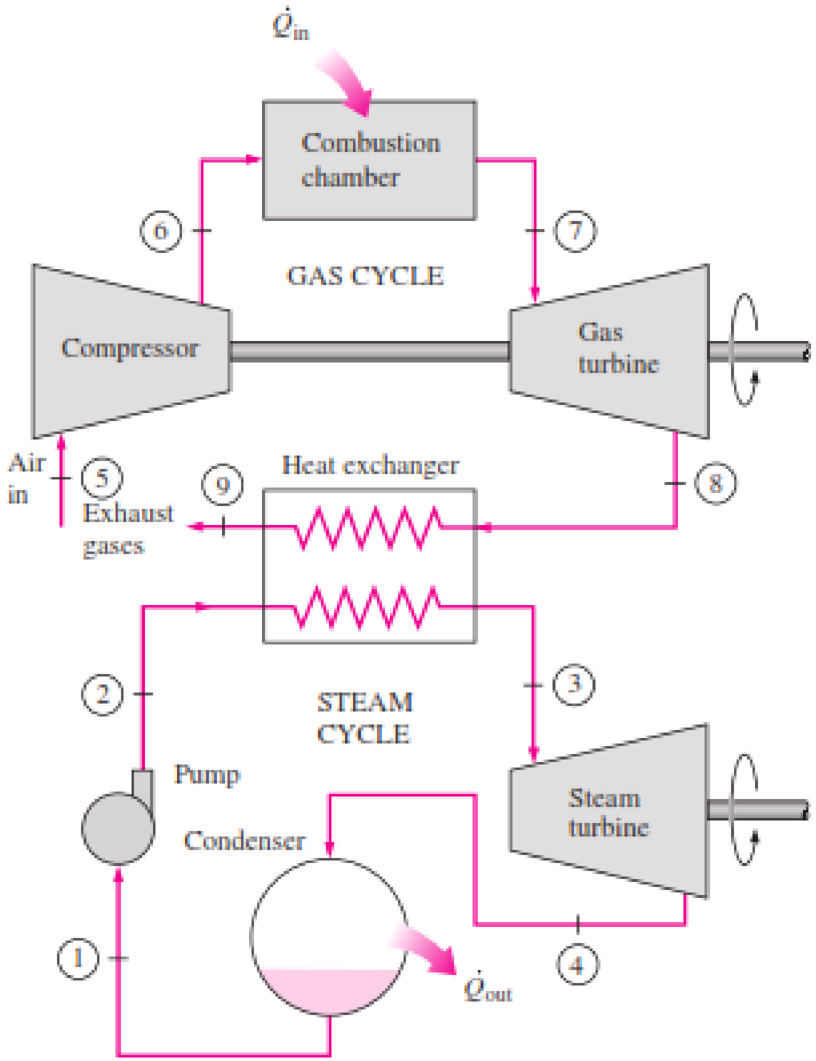




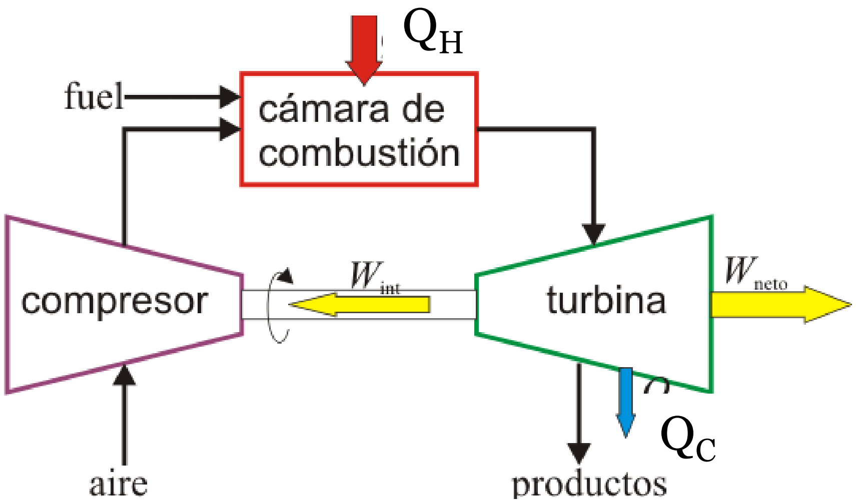

Luz solar
Horno solar
Tendido eléctrico
Fluido conductor
del calor
Luz solar
reflejada
Vapor a presión
Turbina
Generador
Bomba
Helióstato
Terraplén
Generador de vapor
Condensador
Transformador

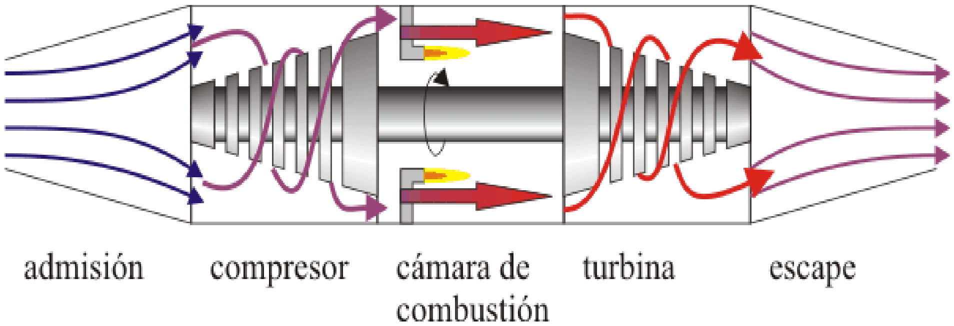

©SolarReserve

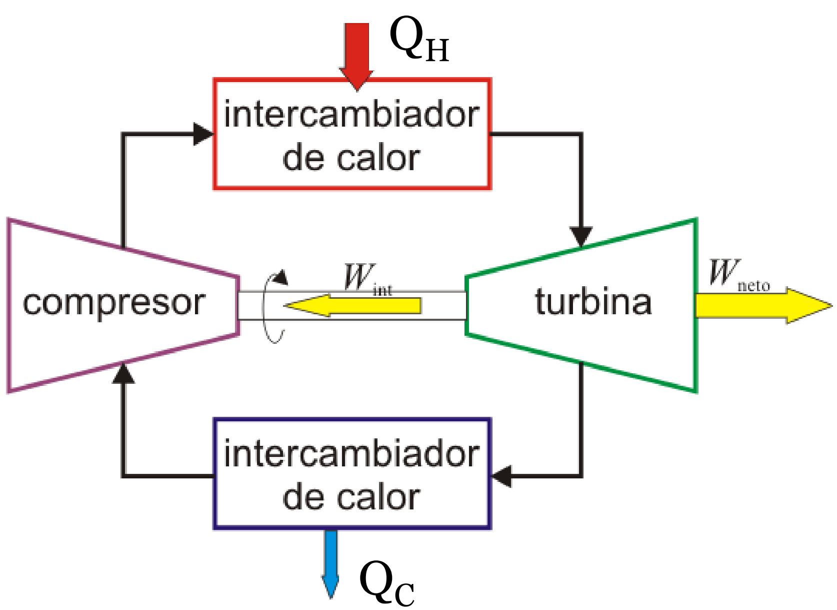
Ciclo Combinado

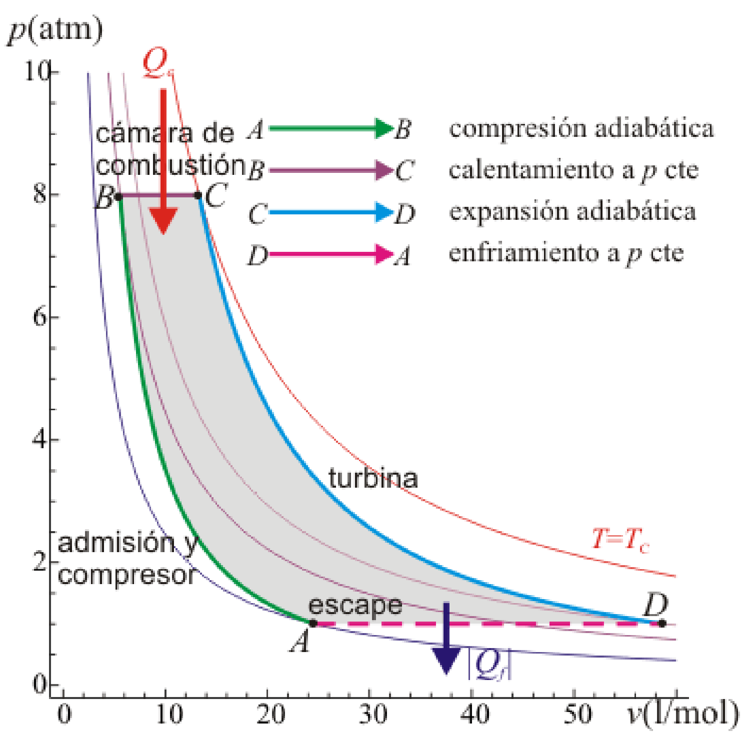


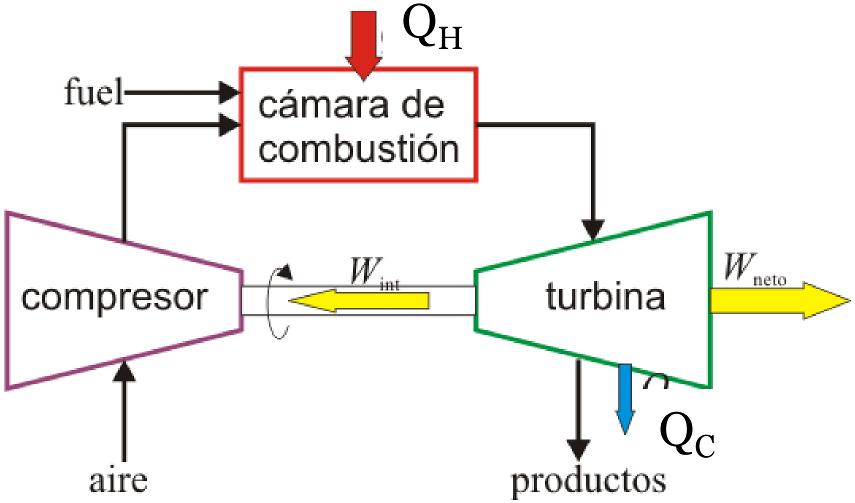
Ciclo Brayton



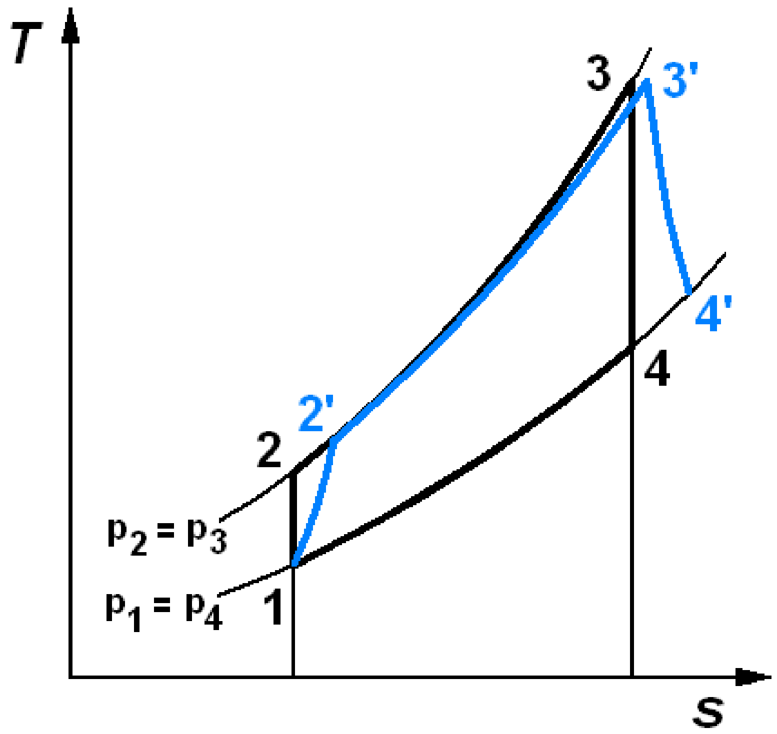




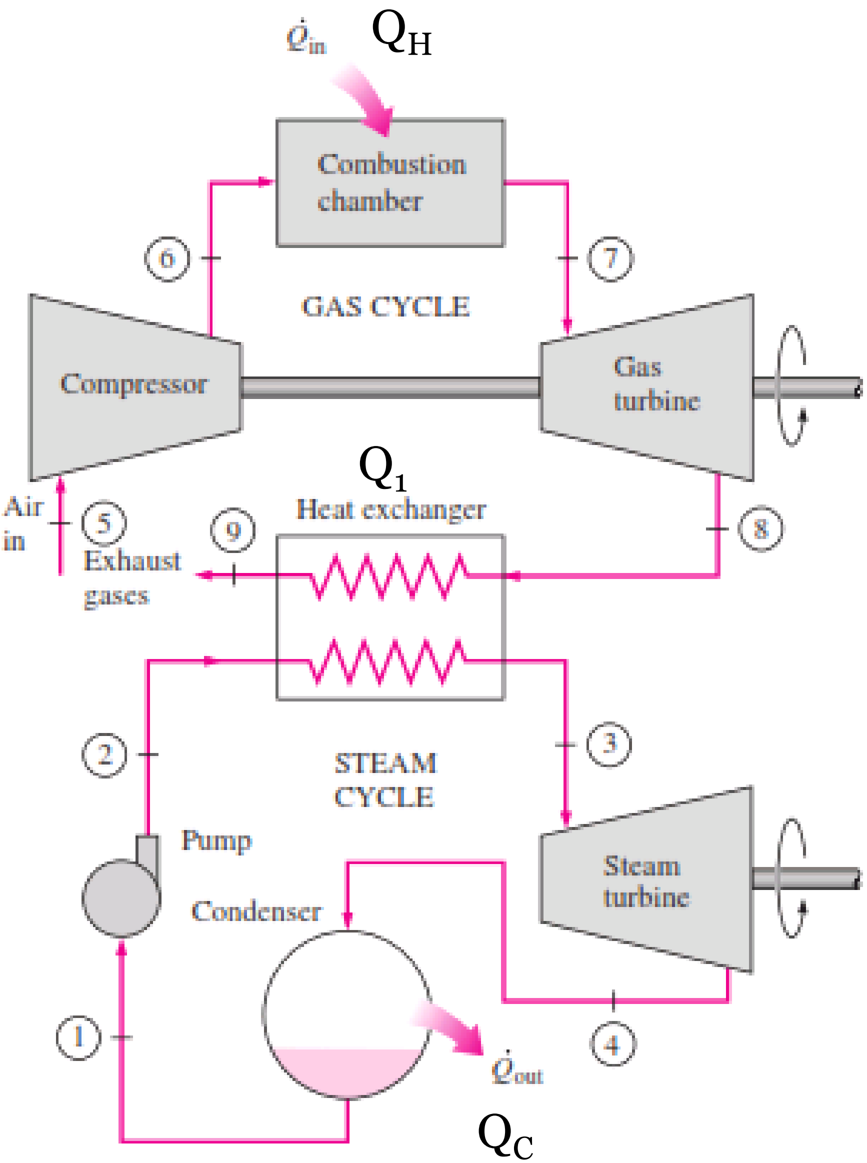




Q_H
fuel
cámara de combustión
compresor
W_int
turbina
W_neto
aire
productos
Q_C



T
3
3'
4'
4
2'
2
p2 = p3
p1 = p4
1
s



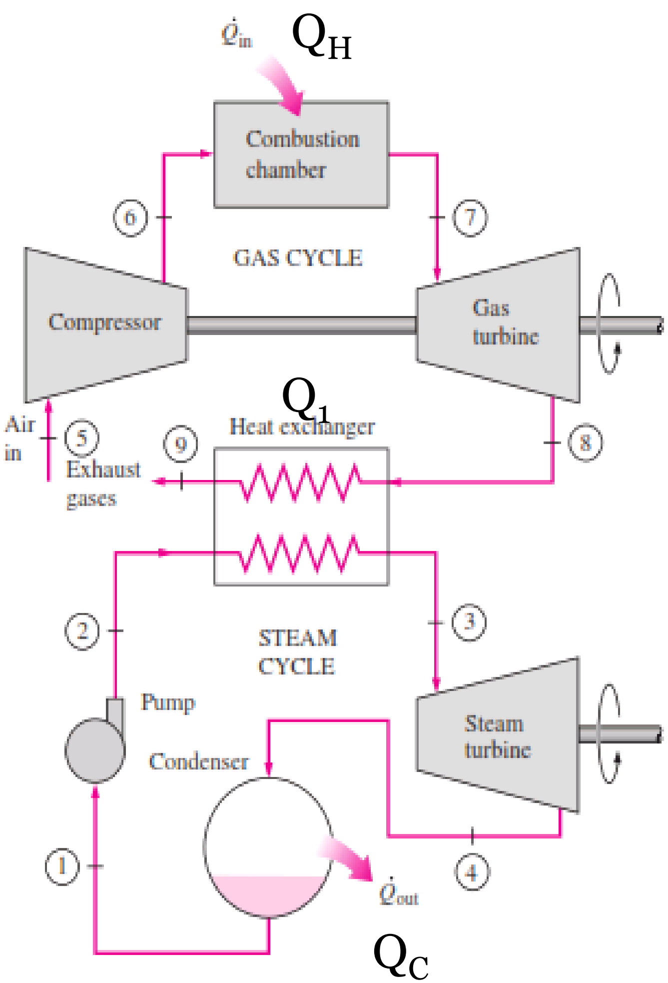
$$\eta \equiv \frac{|W|}{|Q_H|} = 1 - \frac{|Q_C|}{|Q_H|}$$

$$\eta \equiv \frac{|W|}{|Q_H|} = \frac{|W|_{Brayton} + |W|_{Rankine}}{|Q_H|}$$

$$|W|_{Brayton} = |Q_H| - |Q_1|$$

$$|W|_{Rankine} = |Q_1| - |Q_C|$$

$$\eta = \frac{|Q_H| - |Q_1| + |Q_1| - |Q_C|}{|Q_H|}$$



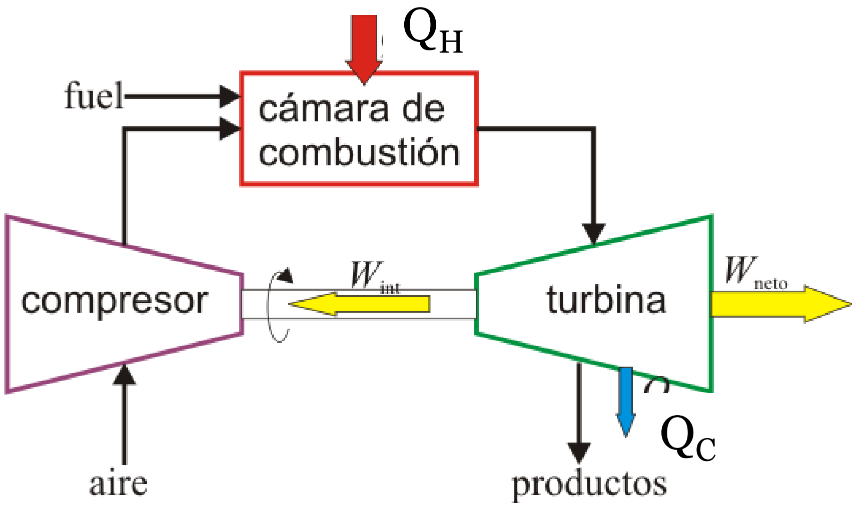
$$\eta = \frac{|Q_H| - |Q_1| + |Q_1| - |Q_C|}{|Q_H|}$$

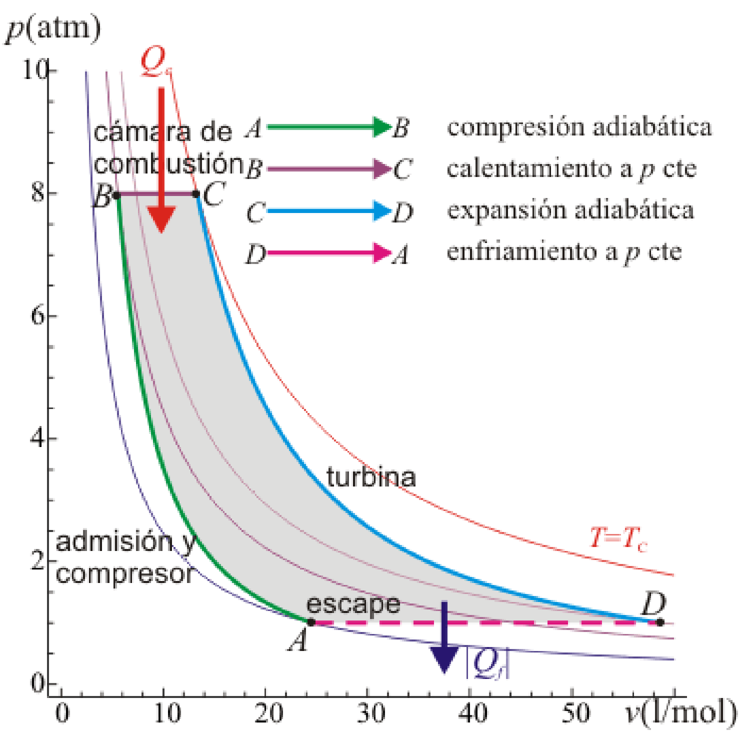
$$\eta = \left(1 - \frac{|Q_1|}{|Q_H|}\right) + \left(\frac{|Q_1|}{|Q_H|} - \frac{|Q_C|}{|Q_H|}\right)$$

$$\eta = \left(1 - \frac{|Q_1|}{|Q_H|}\right) + \left(1 - \frac{|Q_C|}{|Q_1|}\right)\frac{|Q_1|}{|Q_H|}$$

$$\eta = \eta_B + \eta_R(1 - \eta_B)$$

$\eta_R \approx 0.3$ $\eta_B \approx 0.4$ $\eta = 0.58$





$$\eta \equiv \frac{|W|}{|Q_H|} = 1 - \frac{|Q_C|}{|Q_H|}$$

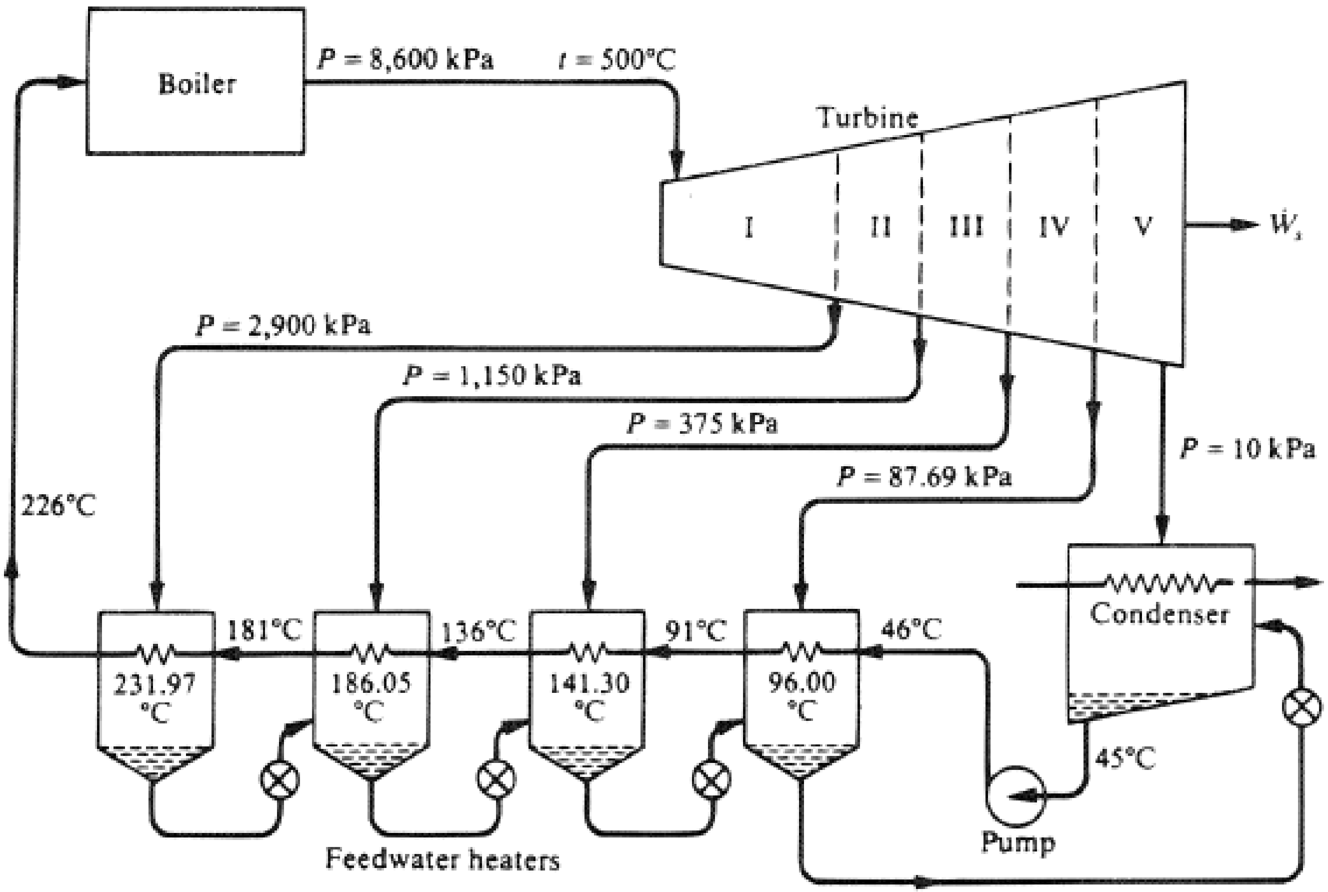
$$\eta = 1 - \frac{C_p\left(T_D - T_A\right)}{C_p\left(T_C - T_B\right)}$$

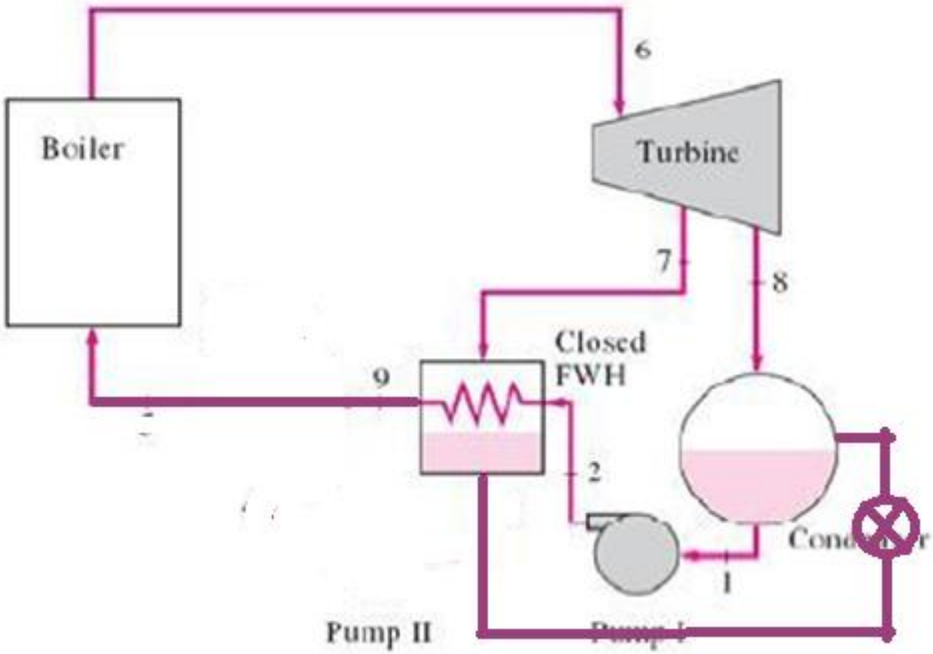
$$\frac{P_A^{1-\gamma}T_A^{\gamma} = P_B^{1-\gamma}T_B^{\gamma}}{P_D^{1-\gamma}T_D^{\gamma} = P_C^{1-\gamma}T_C^{\gamma}}$$

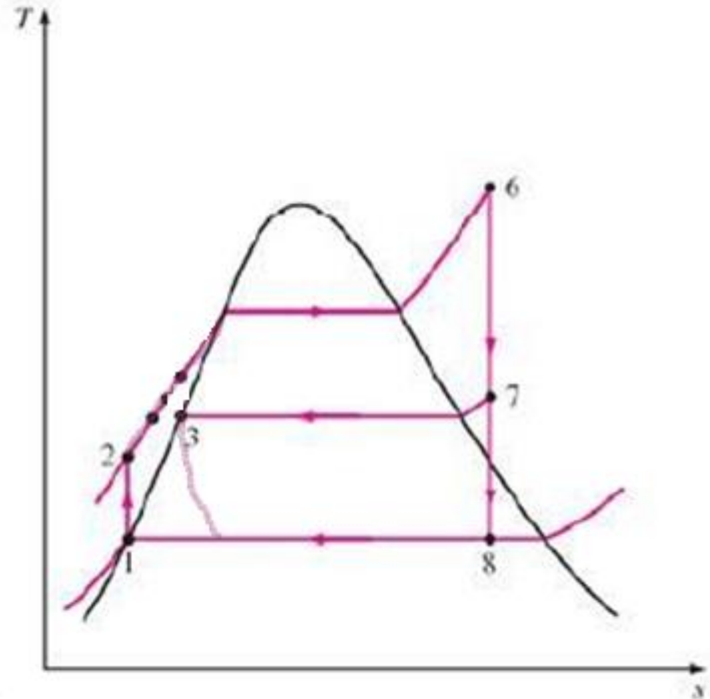
$$\frac{T_A}{T_D} = \frac{T_B}{T_C}$$

$$\eta = 1 - \frac{T_A}{T_B} = 1 - \left(\frac{P_A}{P_B}\right)^{\frac{\gamma - 1}{\gamma}}$$

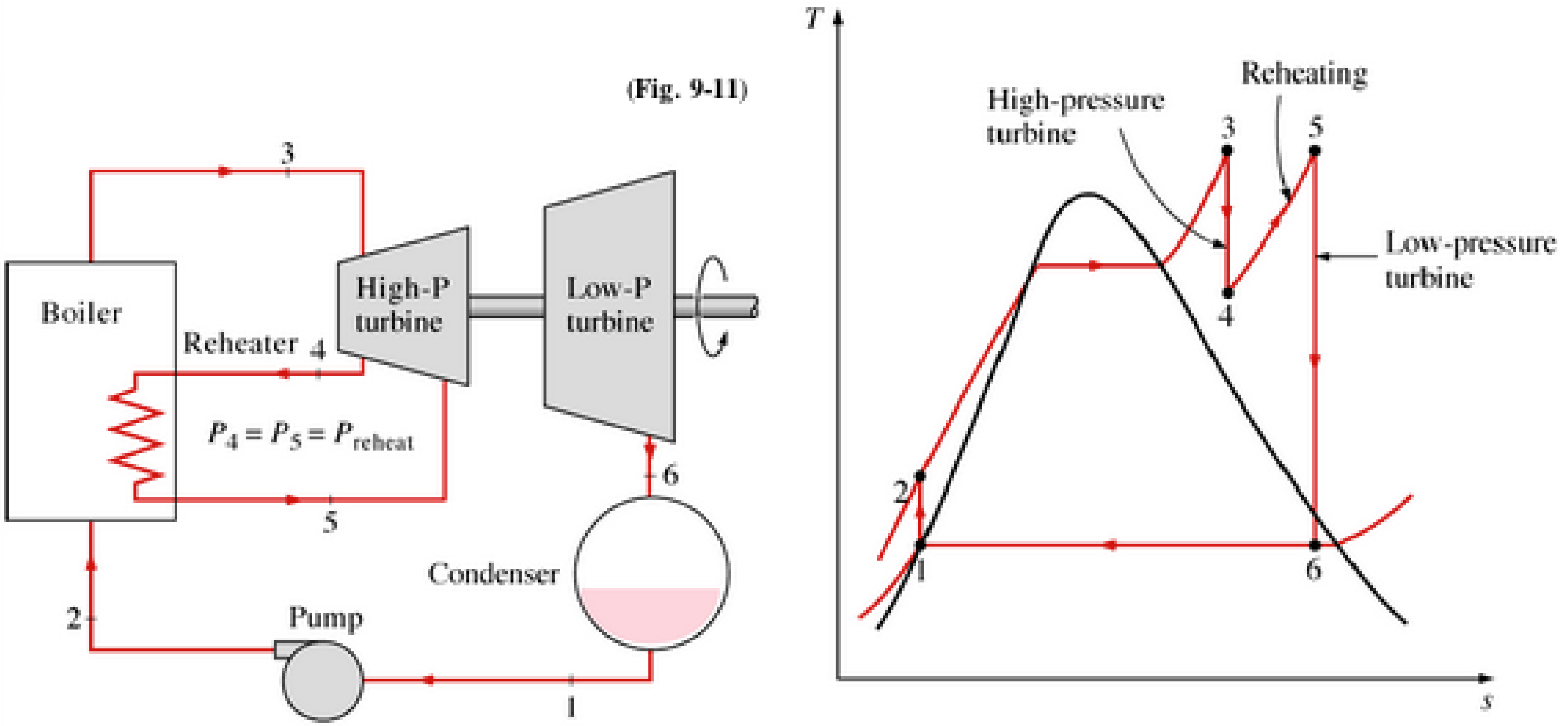
Ciclo Regenerativo

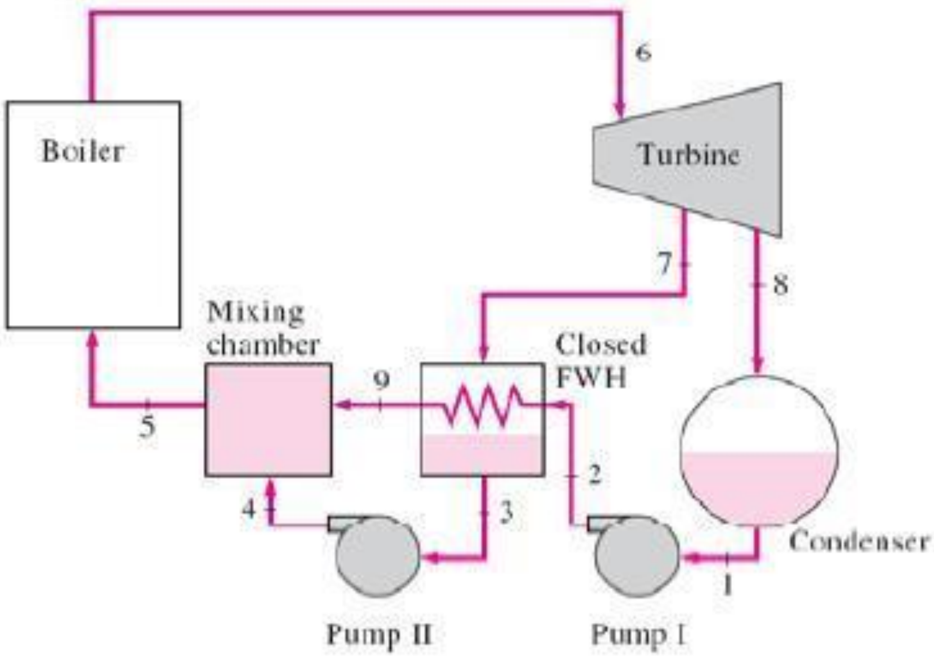


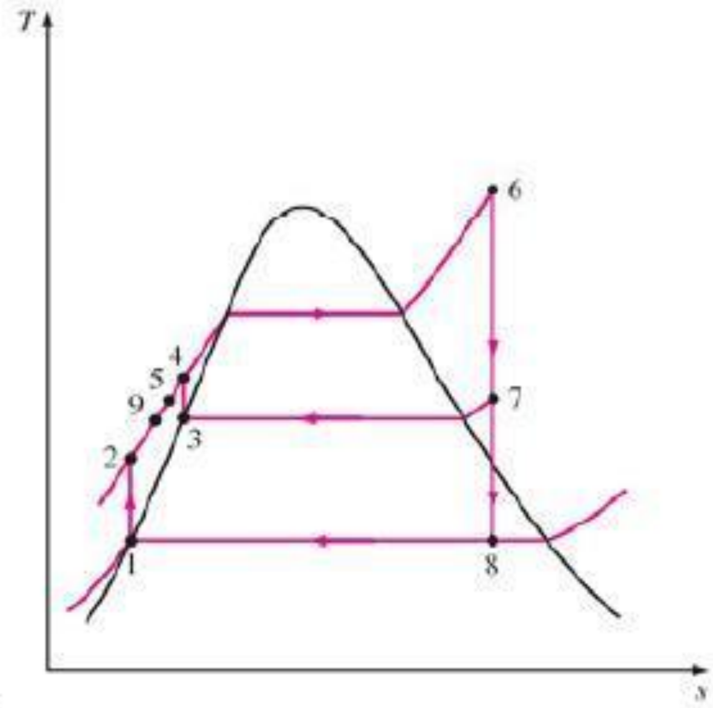

Boiler
Turbine
6
7
8
Closed
FWH
9
2
1
Pump II


T
s
6
7
3
2
1
8

Ciclo con recalentamiento



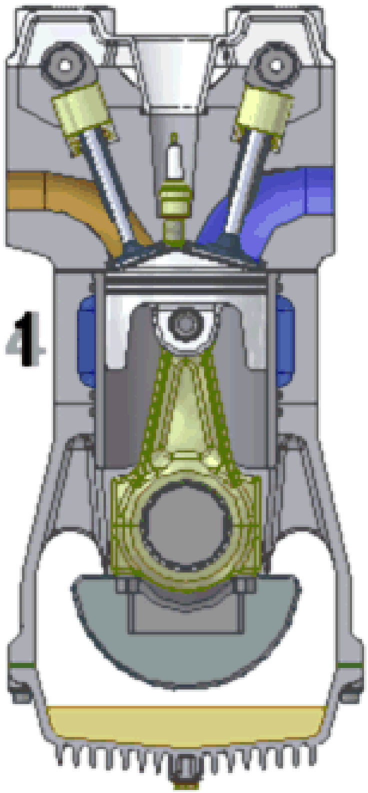

Boiler
Turbine
Mixing chamber
Closed FWH
Condenser
Pump II
Pump I
1
2
3
4
5
6
7
8
9

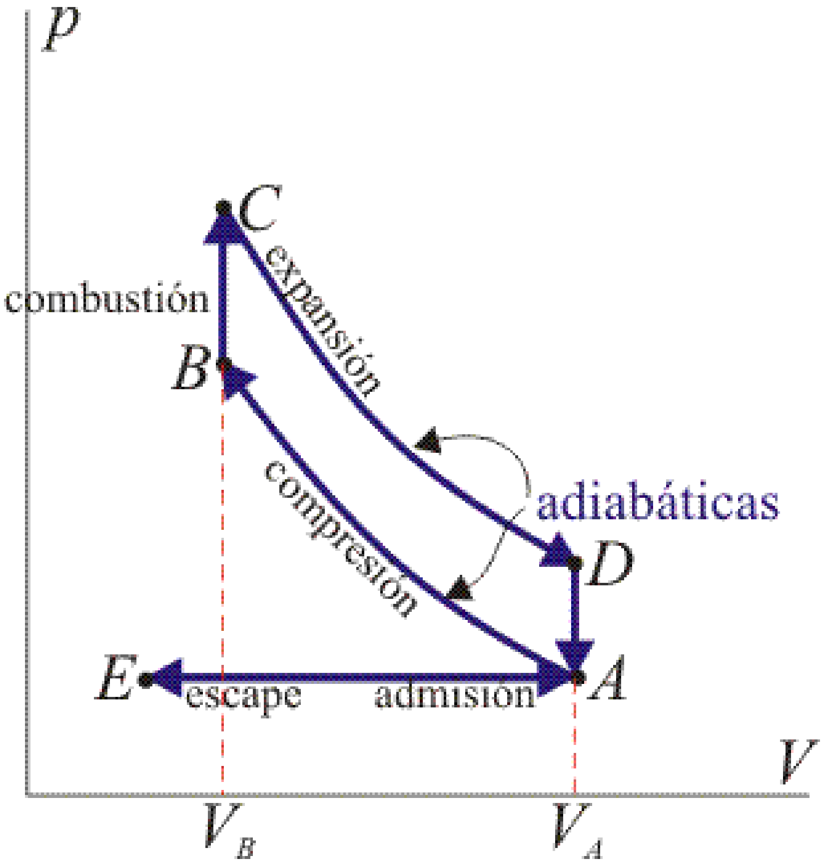

T
s
1
2
3
4
5
6
7
8
9

Motores de combustión interna

- Los mismos gases de combustión son el fluido de trabajo.
- No hay ciclo.
- No hay superficies para la transferencia de calor.
- Puede hacerse un análisis termodinámico simplificado considerando un ciclo de aire que absorbe un calor igual al de combustión.

Ciclo de Otto

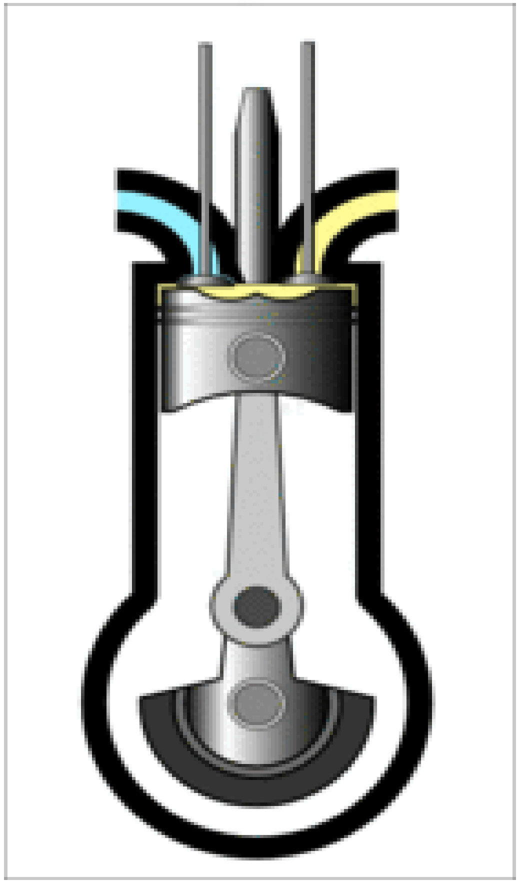


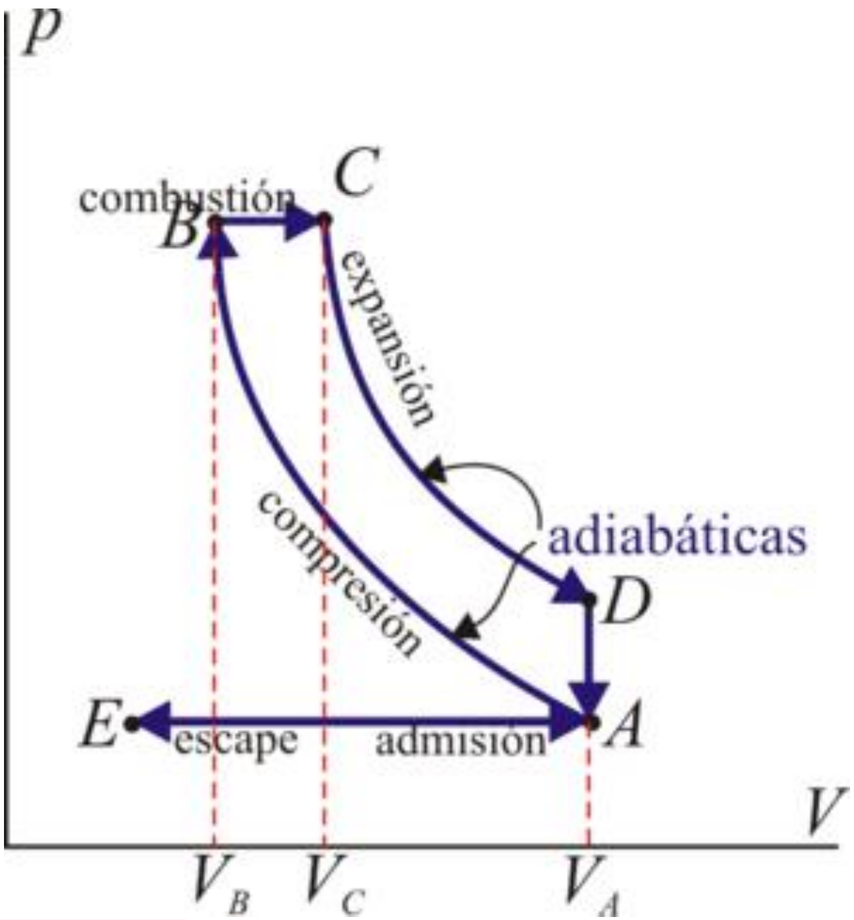


$$\eta = 1 - r\left(\frac{1}{r}\right)^{\gamma-1}$$

$$r = \frac{V_C}{V_D}$$

Ciclo Diesel





$$\eta = 1 - \frac{1}{\gamma}\left[\frac{(1/r_e)^{\gamma} - (1/r)^{\gamma}}{(1/r_e) - (1/r)}\right]$$

$$r = \frac{V_A}{V_B} \qquad r_e = \frac{V_D}{V_C}$$