

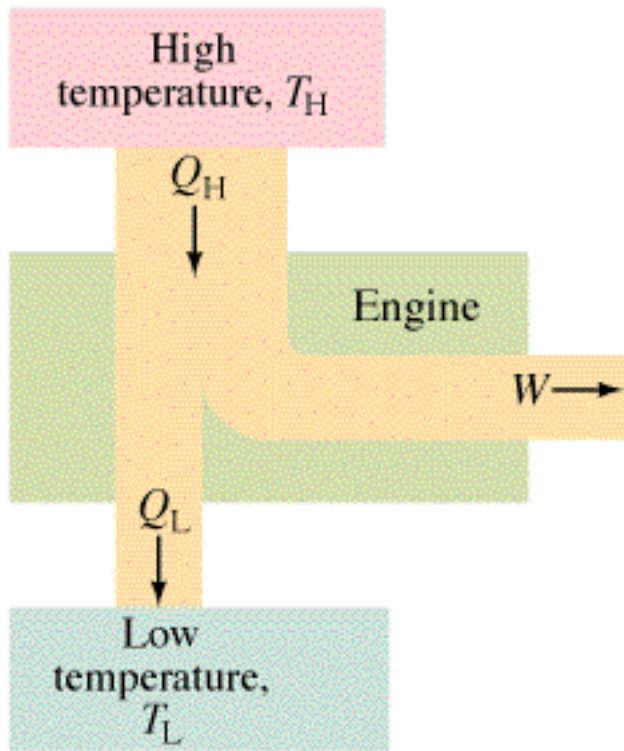
Ch 15. Thermodynamics

I. The First Law of Thermodynamics

$$\text{Closed system: } \Delta U = Q - W$$

U	Internal energy: all the energy of the molecules
ΔU	change in internal energy
Q	+ for heat added; - for heat lost
W	+ work done by the system; - work on system

II. Heat Engine

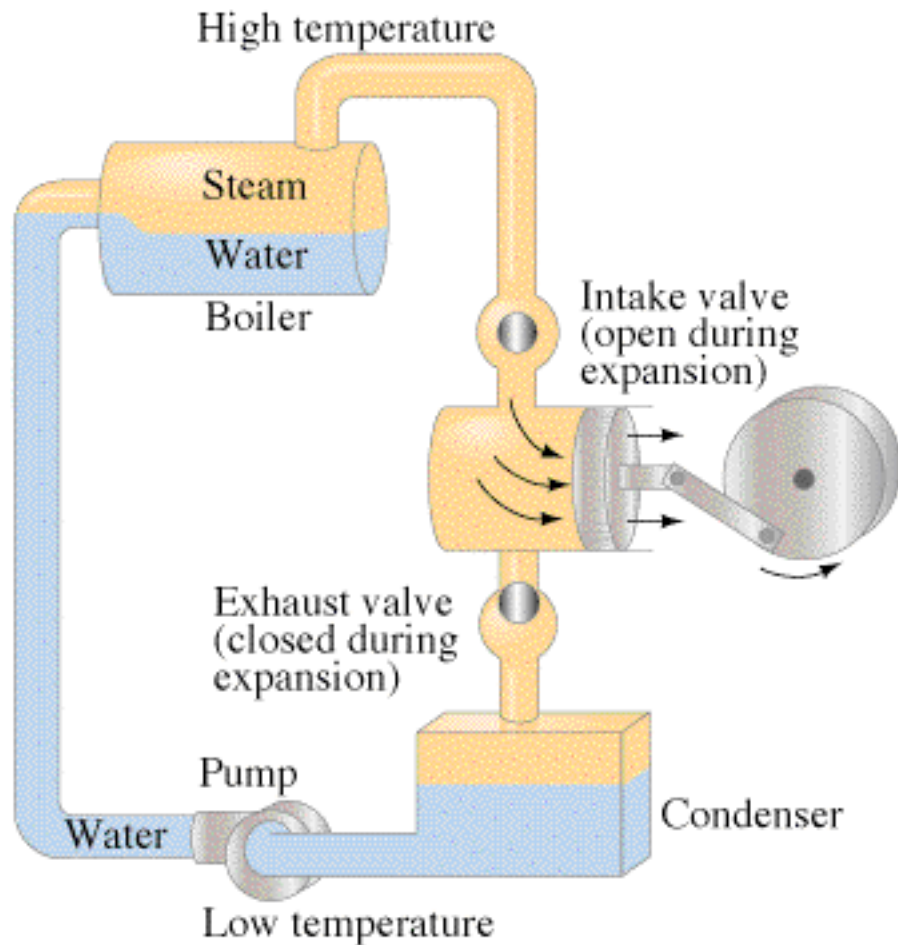


Efficiency (x100%)

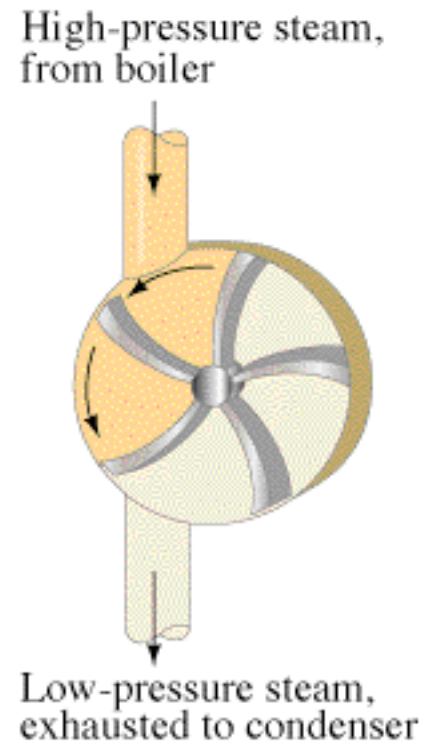
$$\begin{aligned} e &= W/Q_H \\ &= (Q_H - Q_L)/Q_H \\ &= 1 - Q_L/Q_H \end{aligned}$$

$$e < 1$$

Steam Engine

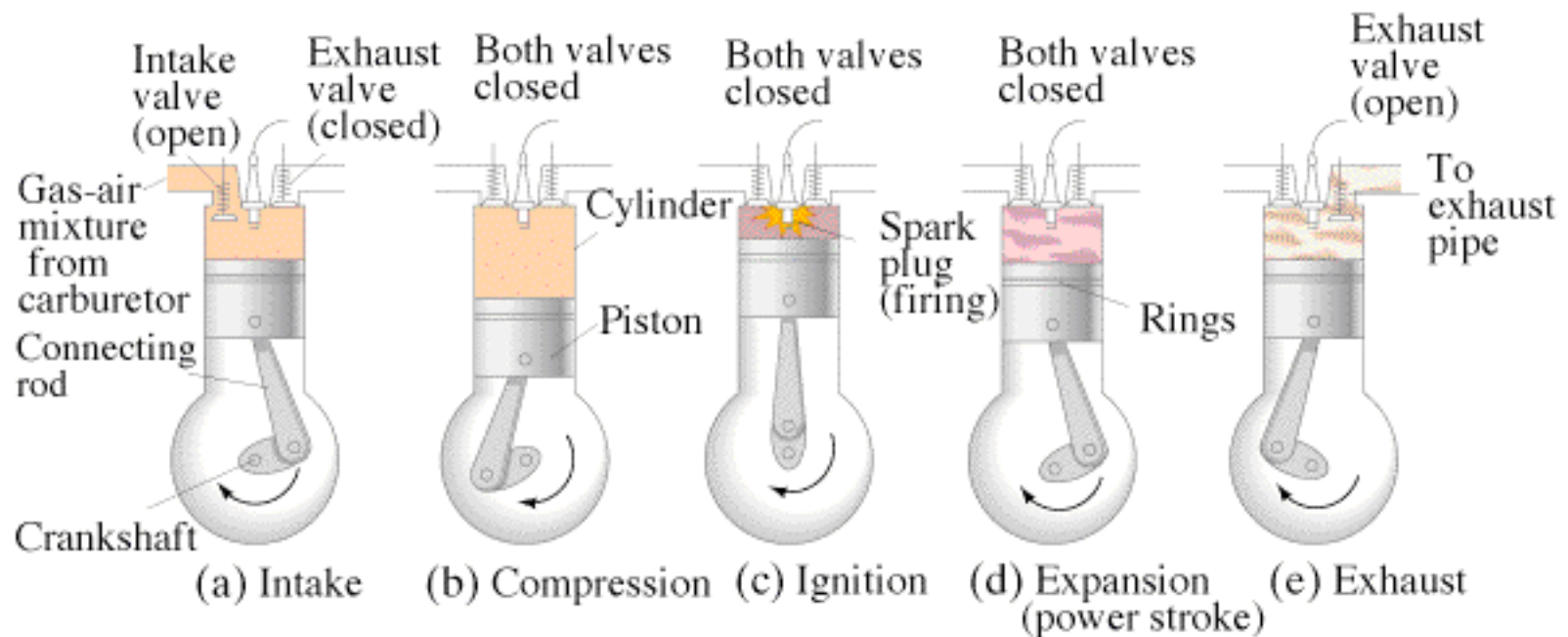


(a) Reciprocating type

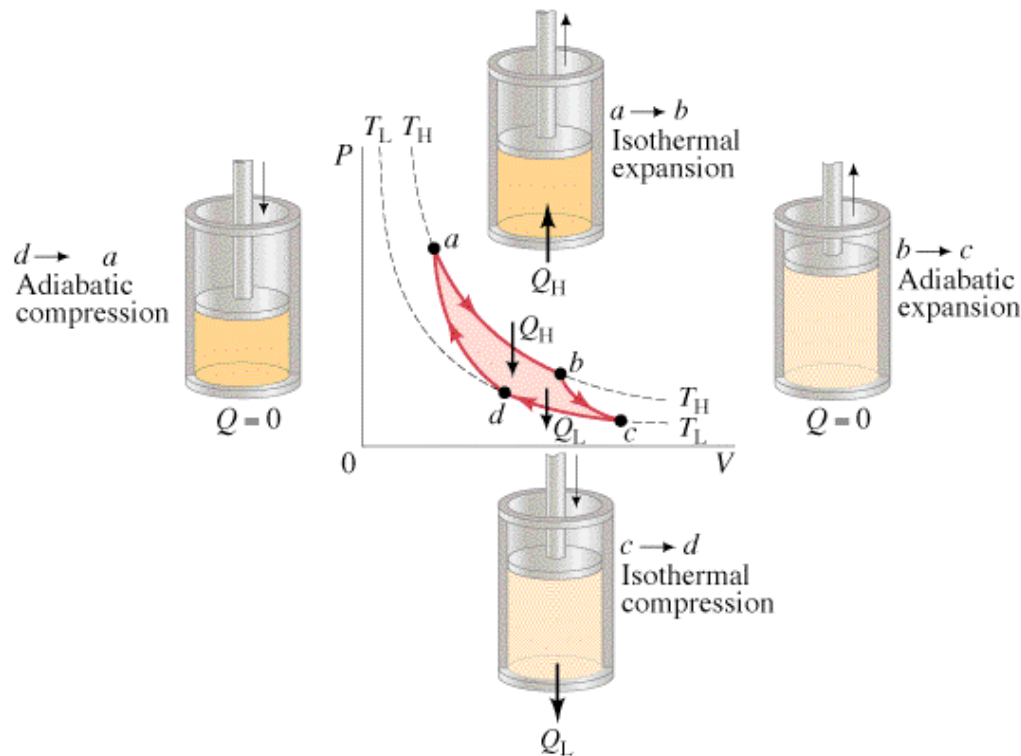


(b) Turbine (boiler and condenser not shown)

Combustion Engine



Carnot Engine



Ideal engine, reversible process

$$Q_H \sim T_H$$

$$Q_L \sim T_L$$

$$e_{ideal} = 1 - Q_L/Q_H = 1 - T_L/T_H$$

(in Kelvin)

Real engine

$$e < e_{ideal} < 100\%$$

Second law of thermodynamics:

No device can transfer a given amount of heat **completely** into work

III. Refrigerator, ac, heat pump

