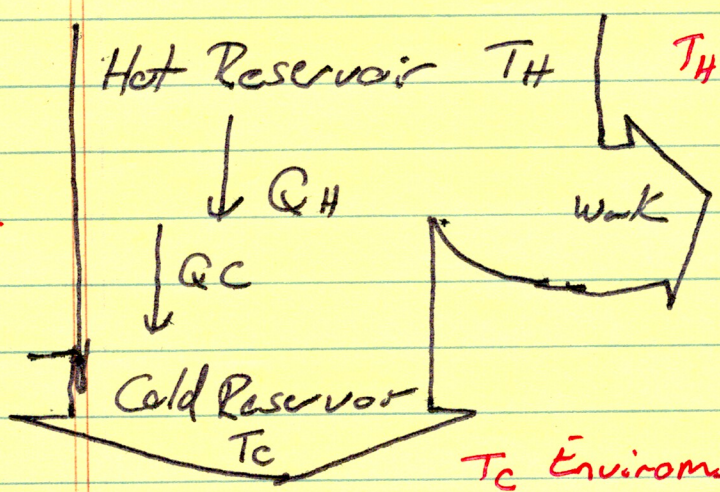
IB: B.2 Carnot Engine & Engine Efficiency (Day 4)

Heat Engine - Cyclic process where heat flows from a hot reservoir to cold reservoir

Ex. Auto Engine, Power Plant

Sankey Diagr.



T_H Chemical Rxn: Burning Oil

$Q_H = W + Q_C$ or
$W = Q_H - Q_C$

T_C Enviroment: Exaust heat from plant to Enviroment

$$\text{Efficiency} = \frac{\text{What}}{\text{Give up}} \qquad \text{Efficacy} = \frac{\text{Work}}{Q_C}$$

IB Data Booklet: $\eta = \frac{\text{useful Work done}}{\text{Energy Input}}$

Heat Engine: $\eta = \frac{Q_H - Q_C}{Q_H}$
Efficacy

or

$$\boxed{\eta = 1 - \frac{Q_C}{Q_H}}$$

- How do ya improve the efficacy of a heat engine

Q_H - Can't change
Q_C - Reduce heat flow into cold reservoir / Envir.

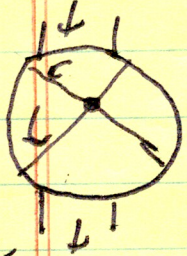
2 sources of heat flow into environment

① Reset System - Need to exhaust heat out of piston to reset process (can not alter)

② Friction / Turbulence (Gas flow) - Increase entropy

No cyclic process can be 100% efficient: Lose heat to reset the system

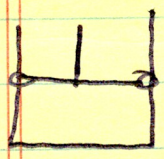
High Pressure Steam



Q_C

Need to reduce pressure to turn turbine
Need to cool gas (use condenser)

Ex. Friction

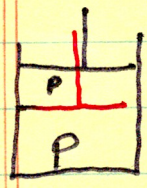


Piston & Walls on side of ~~Extra~~ Cylinder
Friction & Motion → Heat Generated → Q_C into Envir.
System becomes less efficient

Turbulence/Gas Flow

Piston moves up quickly

Flow of Gas



Less Pressure (@ top)
More Pressure (@ btm)

- When you have a flow of gas you have friction, heat energy will be produced → Q_C

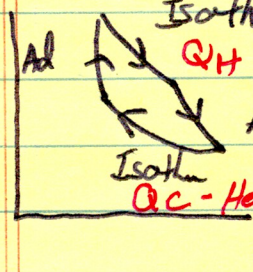
Reversible Engine - No increase in Entropy

- No Friction
- No Turbulence / no gas flow
- Constant P throughout
- PVT well defined
- $|P_{gas}| = |P_{piston}|$ Equilibrium
- Process done slowly Page 2 of 4

Carnot Cycle

Process

Isothermal - Well defined temp & done slowly (Reversible)

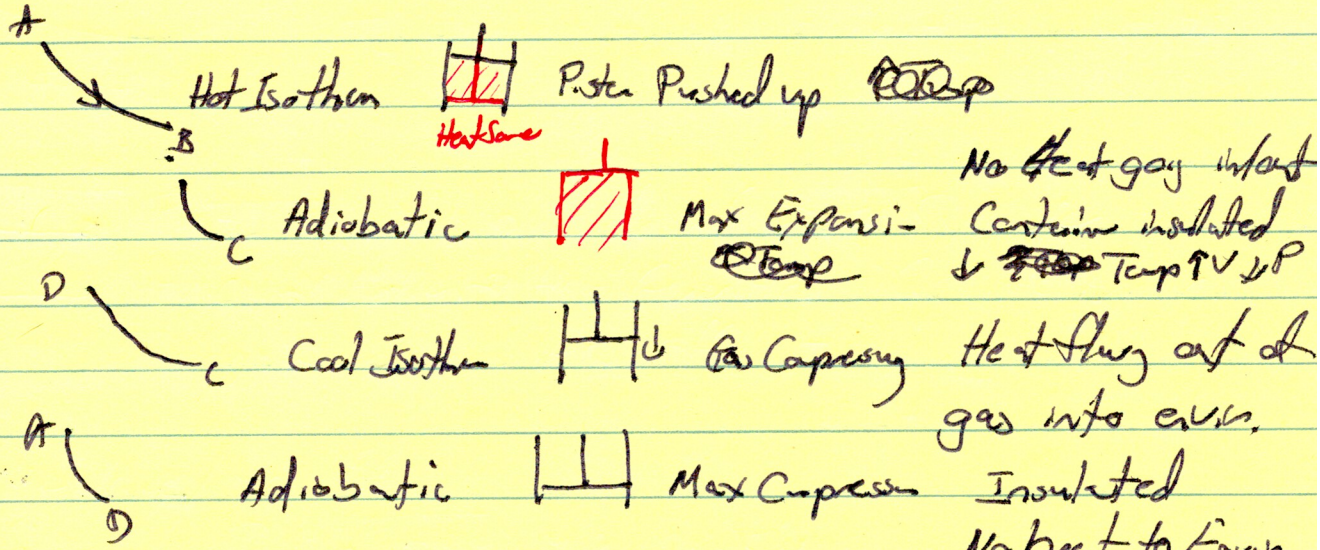


Adiabatic - No Heat flows to Envir $Q=0$ (Reversible)

Area = Work done

For Reversible Engines $\eta = 1 - \frac{T_C}{T_H}$ Need Calc. to prove

Show Carnot Video 17:45



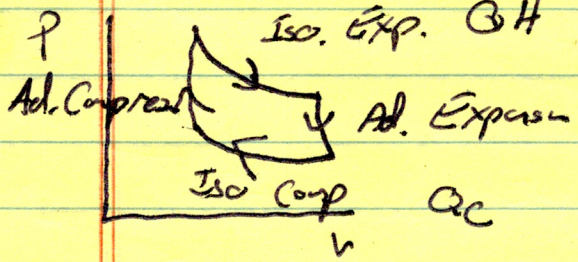
Kelvin Student:

A heat engine can not convert all of the heat energy that it extracts into useful work $Q_H \neq W$

Summary

Carnot Reversible Heat Engine : Most Efficient
→ No Friction
→ No Turbulence / Backflow

Consist of Isotherm & Adiabatic process



Work done in closed Area
+ Work done
because Press. high during Exp. than Comp
Gain

Shared $\eta = 1 - \frac{T_C}{T_H}$ $\eta = 1 - \frac{Q_C}{Q_H}$