Carnot cycle

- The Carnot cycle , is a thermodynamic process, that describes how a fluid is used to convert thermal energy into work.

- Nicolas Léonard Sadi carnot.
- It is related to the theory of heat engines.

characteristics

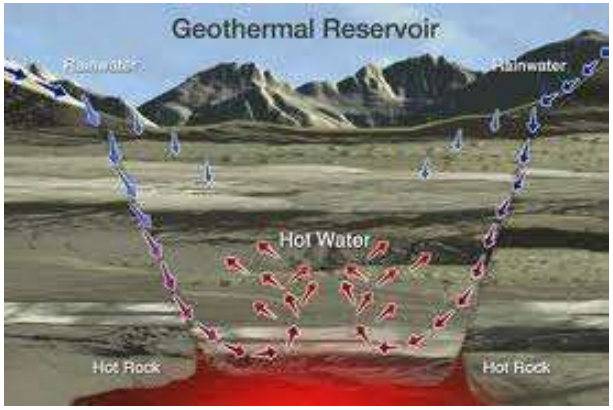
- High Efficiency
- Multi-Source Engine
- Better reliability and easier maintenance
- Reversible
- Safe, discrete and oxygen-free
- Modularity and flexibility

High Efficiency

- Most engines have a thermodynamic limit of 37% (little bit higher for diesel engines).
- Practical efficiency depends of temperature level and differences.
- Waste heat is easily harvested (compared to waste heat from an internal combustion engine) making Carnot engines useful for dual-output heat and power systems

Multi-Source Engine

- Carnot engines can run directly on any available heat source.



Better reliability and easier maintenance

- The engine mechanisms are in some ways simpler than other reciprocating engine type.
- No valves are needed, and the burner system can be relatively simple.
- Unlike other technologies, the Carnot engine is very suitable for low temperature.

Safe, discrete and oxygen-free

- A Carnot engine uses a single-phase working fluid thus for a properly designed system the risk of explosion is low.
- In comparison, a steam engine uses a two-phase gas/liquid working fluid, so a faulty release valve can cause an explosion.
- Moreover the Carnot engine can be built to run quietly and without an air supply, for air-independent operation (i.e: submarines).

Modularity and flexibility

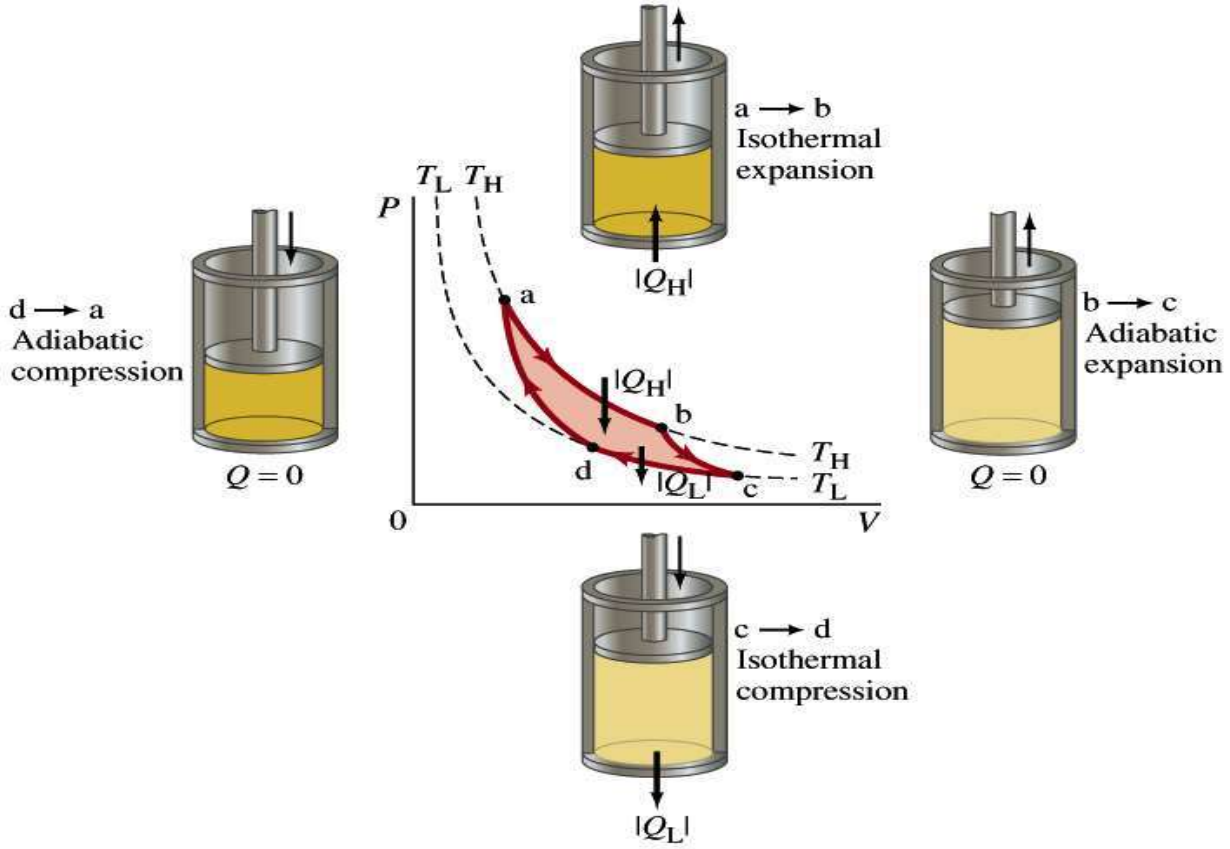
- Possibility to use the same engine for different applications with only minor modifications.
- Moreover, the Carnot architecture allows to develop a wide range of power based on the same design. It means the possibility of scaling up or down the engine power without the need of costly and time consuming design studies.

P–V diagram

- A **pressure volume diagram** is used to describe corresponding changes in volume and pressure in a system.
- The PV diagram, called an indicator diagram, was developed by James Watt and his employee John Southern (1758–1815) to improve the efficiency of engines.

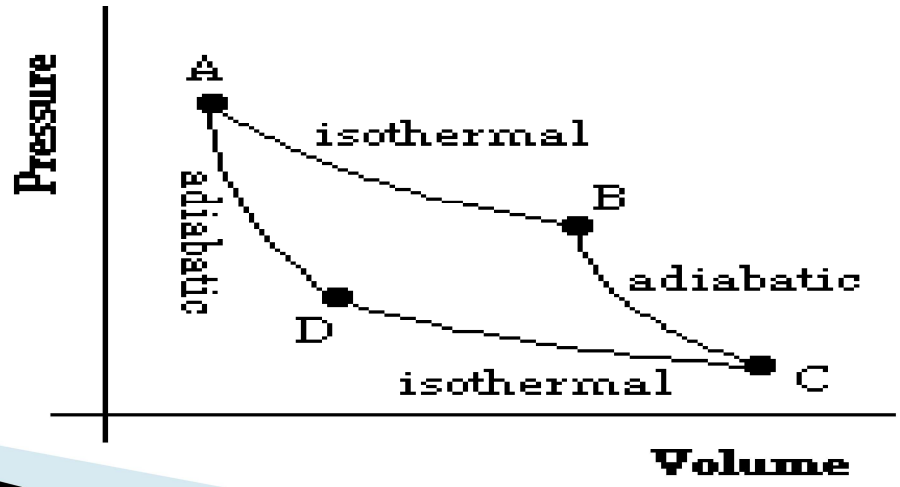
PV diagram

- This is the PV diagram.



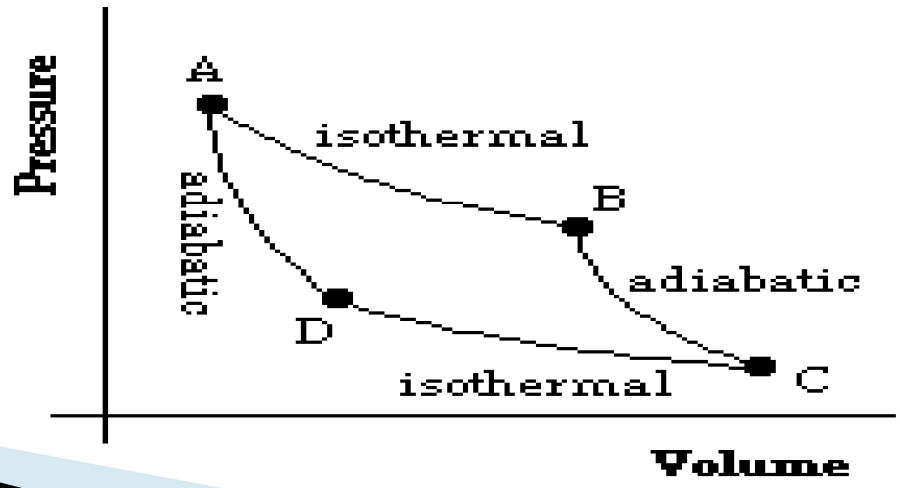
Cont..

- **isothermal** segments (AB and CD) occur when there is perfect thermal contact between the working fluid and one of the reservoirs, so that whatever heat is needed to maintain constant temperature will flow into or out of the working fluid, from or to the reservoir.



Cont..

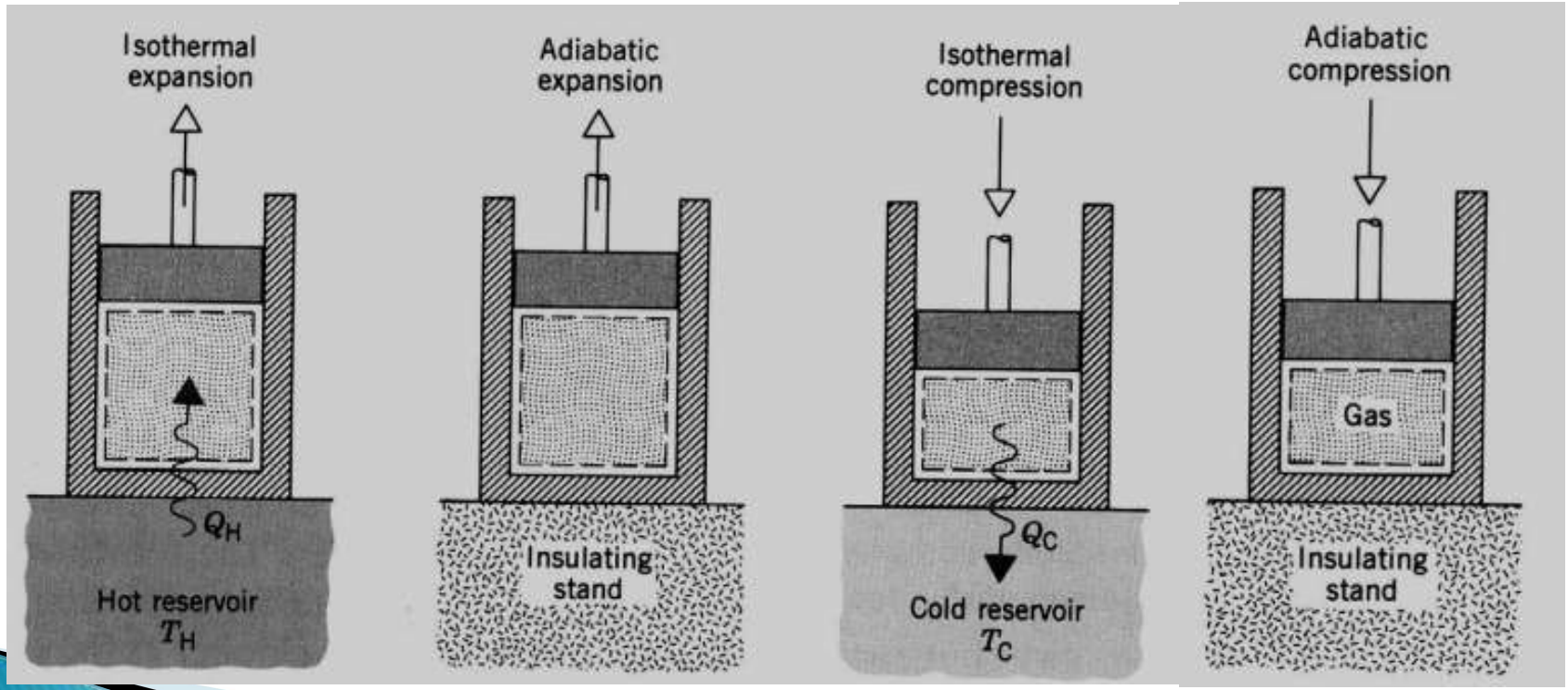
- the **adiabatic** segments (BC and DA) occur when there is perfect thermal insulation between the working fluid and the rest of the universe, including both reservoirs, thereby preventing the flow of any heat into or out of the working fluid.



Sequence of operation

- Phases of the Carnot's Cycle
  The sequence of steps in the Carnot's
  - Reversible isothermal expansion (1–2, T_H=constant)
  - Reversible adiabatic expansion (2–3, Q=0, $T_H \rightarrow T_L$)
  - Reversible isothermal compression (3–4, T_L=constant)
  - Reversible adiabatic compression (4–1, Q=0, $T_L \rightarrow T_H$)

sequence


Isothermal expansion
Adiabatic expansion
Isothermal compression
Adiabatic compression
Q_H
Hot reservoir
T_H
Insulating stand
Q_C
Cold reservoir
T_C
Gas
Insulating stand

Thermal efficiency

- In thermodynamics, the thermal efficiency is a measure of performance of a device that uses thermal energy.
- For example:
- an internal combustion engine, a steam turbine or a steam engine, a boiler, a furnace, or a refrigerator for example.

Cnt….

- The Carnot Cycle is an entirely theoretical thermodynamic cycle utilizing reversible processes.
- The ultimate thermal efficiency can then be used to compare the efficiencies of other cycles operating between the same two temperatures.

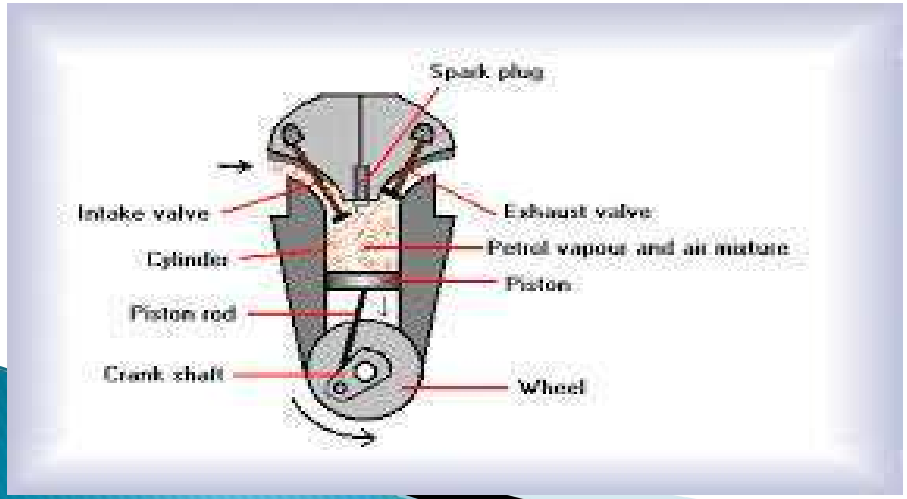
Cnt..

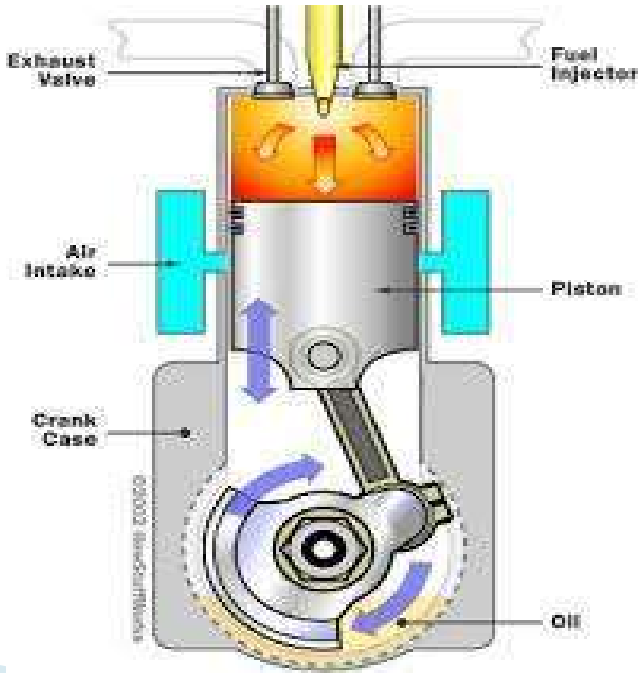
- The thermal efficiency of any engine working between the temperatures of T_1 and T_2 is:
- i.e. increase the temperature difference under which the engine works.

$$e = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$$

Applications

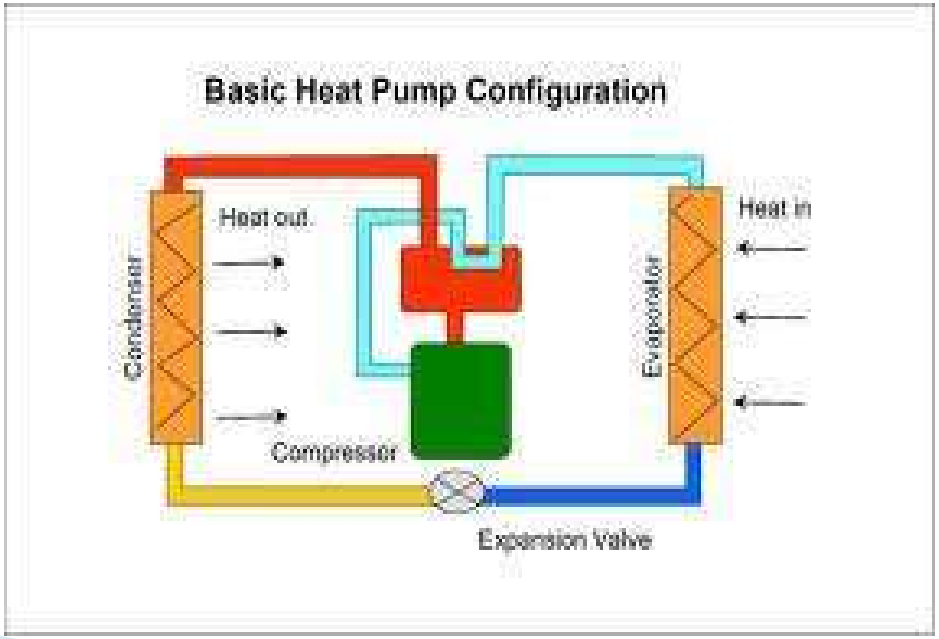
- 1) All types of vehicles that we use, cars, motorcycles, trucks, ships, aero planes, and many other types work on the basis of second law of thermodynamics and Carnot Cycle. They may be using petrol engine or diesel engine, but the law remains the same.





Applications

- 2) All the refrigerators, deep freezers, industrial refrigeration systems, all types of air-conditioning systems, heat pumps, etc work on the basis of the Carnot cycle.



Application