Date:- 13/05/2022.

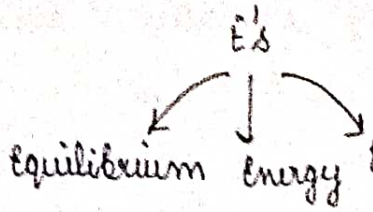
Unit: 01

Thermodynamics :-

Thermodynamics is the branch of science which deals with energy interaction of the system with the surrounding. and its impact on the properties of system.

'or'

Thermodynamics is a branch of science which deals with the study of three E's.



- System :-

Anything under the consideration or it is a controlled region in the space over which our attention is focussed.

- Surrounding :-

Everything external to the system

- Boundary :-

It seperated the system and surrounding. Boundary can be real or imaginary.

Real boundaries are represented by continious line or curve.

Boundary can be fixed or can be movable.

It should be considered of nearly zero thickness

Imaginary boundary is represented by dotted curve.

- Universe :-

Summation of system and surrounding is known as universe

• Types of system:-

There are three types of system

a) Open system:-

It is the system in which both mass and energy interaction takes place.

Eg:- Boiler, Turbine, Condenser, evaporator, Heat exchanger, pump etc.
piston cylinder arrangement with valve.

b) Closed system:-

It is the system in which only energy interaction takes place

Eg:- Piston cylinder arrangement without valve.

c) Isolated system:-

In the system in which neither mass interaction nor energy interaction takes place.

Eg:- thermos flask, universe.

• Microscopic approach vs Macroscopic approach.

In microscopic approach individual molecules under attention. It is also known statical approach.

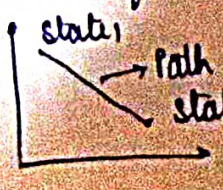
In macroscopic approach the time average behaviour of the molecule is under consideration.

The time average behavior is under condiration and is also known as classical approach.

In our thermodynamics we are generally dealing with macroscopic approach.

• Thermodynamic state:-

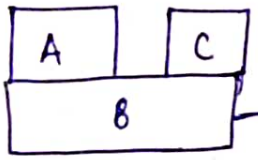
It is representing the condition of the system.



• Path:-
The path is obtained by joining the two equilibrium state.

• First law of thermodynamics:-

• Zeroth law of thermodynamics:-
It is given by RH Fowler. According to this if the th body A is in thermal equilibrium with body B and body B is in thermal equilibrium with body C seperately. Then body A and C will be in thermal equilibrium with each other.
The role played by common body is of thermometer.
Zeroth law of thermodynamics provide the concept of thermal equili-brium.



→ The role played by common body is of thermometer.

$T_A = T_B$ - ①

$T_B = T_C$ - ②

Then from ① and ②

$\boxed{T_A = T_C}$

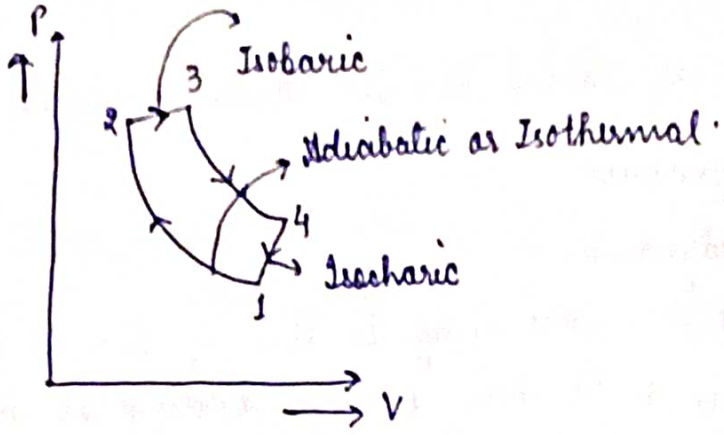
• First law of thermodynamics:-
Energy can neither be created nor be destroyed. It can only be converted from one form to another.

'or'

The cyclic integral of net heat is equal to the cyclic integral of net work done

$$\oint \delta Q = \oint \delta W.$$

This law of is verified for cyclic process closed system.



Entropy = $\frac{dQ}{dt}$

Since in adiabatic $dQ=0$

thus

Entropy = 0.

According to first law:-

$$Q_{1-2} + Q_{2-3} + Q_{3-4} + Q_{4-1} = W_{1-2} + W_{2-3} + W_{3-4} + W_{4-1}$$

$$\boxed{\partial Q = \partial U + \partial W}$$

First law is also known as energy conservation law or quantative law or joule's law.

• Extensive and Intensive property :-

Intensive or Intrensive properties are those properties which are indepent of mass.

for ex:- temperature, pressure, conductivity; specific heat, ratio of extensive property (like density, specific energy (energy per unit mass), coefficient of thermal expansion)

Extensive or Extrensive properties are those properties which are dependent on mass.

for eg:- volume, mass, all form of energy, heat capacity

• Pure Substance :-

It is a substance of constant chemical composition throughout its volume or of mixture irrespective of phase.

for eg :- water + ice.

• Second law of thermodynamics :-

Heat is a form of energy arises due to difference in temperature.

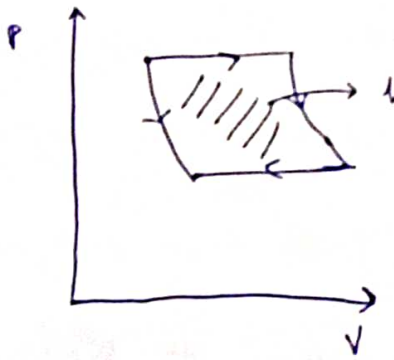
$$\partial Q = \partial U + dW$$

Now,

$$dW = \int P dV$$

for isochoric process $dV = 0$

thus, $W = 0$



work done is given by this area.

If P is constant.

$$dW = P \int_1^2 dV$$

$$= P(V_2 - V_1)$$

for open system

$$\boxed{dW = \int V \cdot dP}$$

• Steam :-

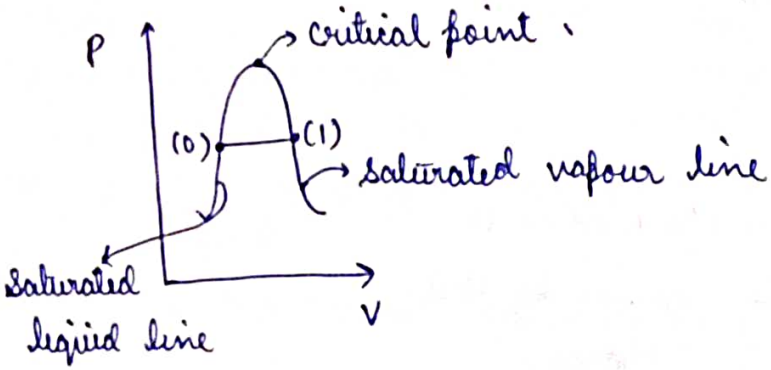
Dryness fraction (x) = $\frac{\text{mass of vapour}}{\text{mass of vapour + mass of liquid}}$

$= \frac{m_v}{m_v + m_L}$ (lie between 0 and 1)

1. A mixture contain 2 kg liquid and 3 kg vapar. Find the dryness factor of mixture.

Sol:- Dryness factor = $\frac{3}{5} = \frac{3}{5} = \frac{60}{100} = 0.6$

• Steam :-



• Boiler :-

A simple boiler may be defined as a closed vessel in which steam is produced from water by combustion of fuel.

According to ASME (American society of Mechanical Engineering) a "steam is generating unit may be defined as a combination of operators for producing furnishing or recovering heat together with the operators for transferring the heat so made available to fluid being heated and vaporised. The steam generated is employed for the following purpose.

i) In steam engine or steam turbine
→ For generating power

ii) For heating the building in cold wather. and for producing hot water supply.

• Classification of boiler :-

a) Horizontal, vertical and inclined :.
b) Fire tube and water tube boiler.
c) Externally and internally fired
d) Forced circulation and natural circulation.
e) High pressure and low pressure boiler.
f) Stationary and portable boiler.
g) Single tube and multi-tube.

Fired Tube

a) Hot gases inside the tube and water outside the tube.
b) Generally internally fired
c) Operating pressure limited to 16 bar
d) The rate of steam production lower
e) Not suitable for large power plant
f) Involves lesser risk on explosion due to lower pressure
g) For a given power it occupies lesser space (floor area) more
h) Construction of fired tube boiler is difficult.
i) Transportation of fixed tube boiler is difficult.
j) For eg :- Lochran, Lancashire, locomotive.

Water tube :-

a) Water inside the tube and hot gases are outside the tube.
b) Generally externally fired.
c) Can work under a high pressure as 100 bar.
d) The rate of steam production is higher.
e) Suitable for large power plant
f) Involves more risk on explosion due to high pressure.
g) For a given power it occupies lesser space. (floor area).
h) Construction of water tube is simple.
i) Transportation of water tube boiler is easy.
j) For eg :- Babcock, wilex, Lamount, Benson.

• Mounting:-

It is a essential part of boiler.

It is used for safety purpose.

Eg:- Feed water indicator, pressure gauge.

• Accessories:-

It is a intigral part of the boiler.

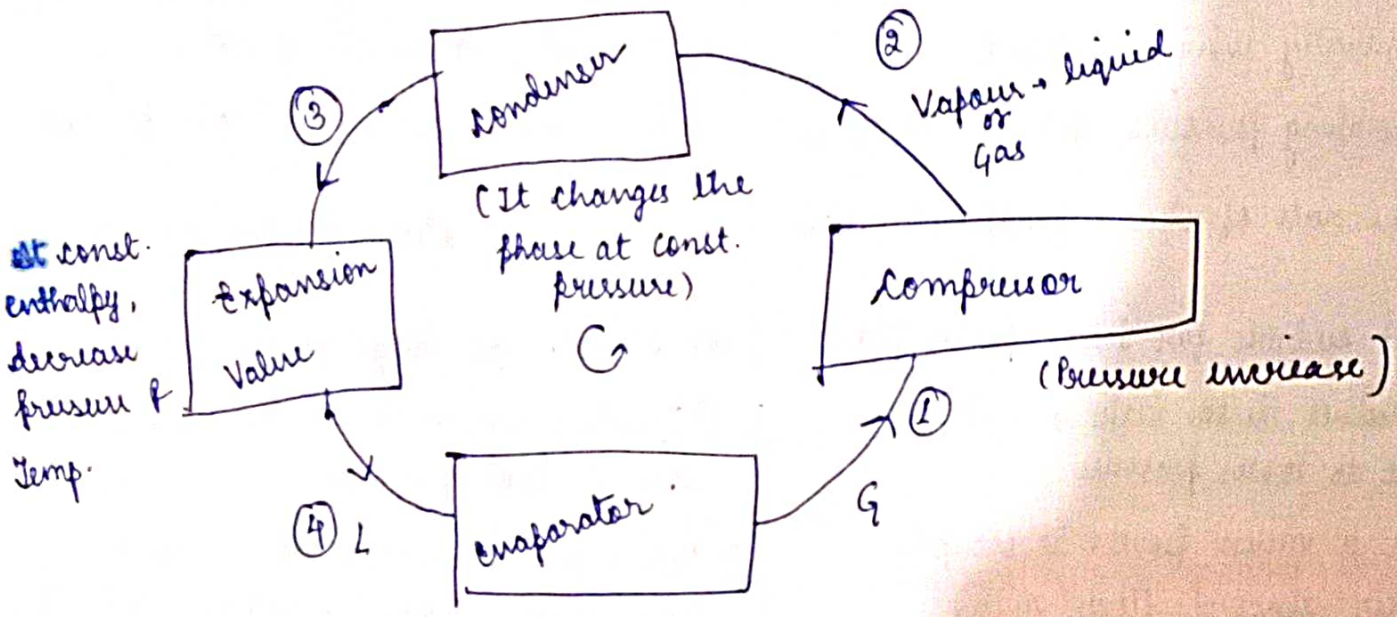
It is used to increase the performance of boiler.

Eg:- Air- pre-heater, economiser.

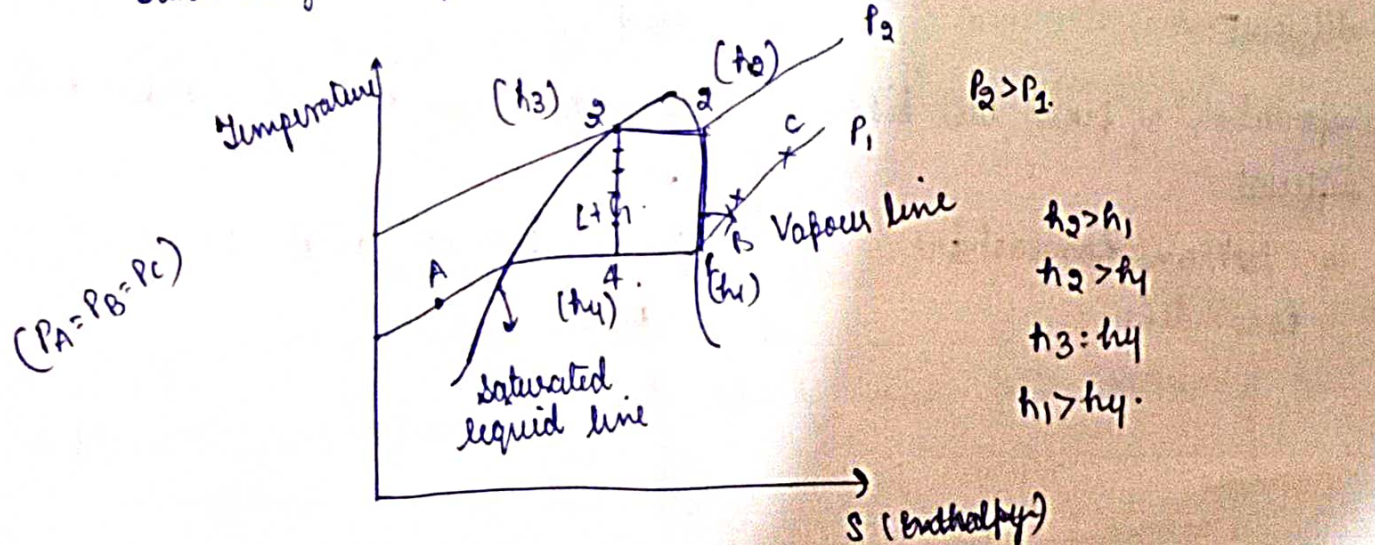
(Increases the initial temperature of the air)

(Increases the temperature of feed water)

• Vapour Compresser refrigeration system:-



Block diagram of VCRS.



• COP of VCRS.

$$\frac{\text{Desired effect}}{\text{Input}}$$

$$= \frac{h_1 - h_4}{h_2 - h_4}$$

1. A VARS system is used to maintain the temperature of 15°C, generator temperature is 75°C and condenser temperature is 30°C. Find the COP of VARS system.

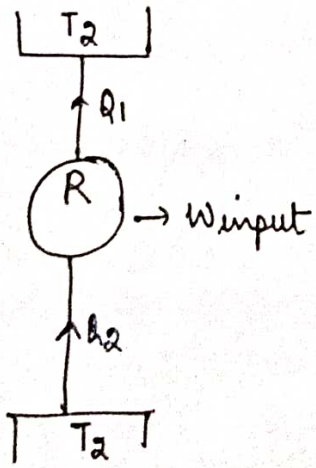
Solution $COP = \left(\frac{T_E}{T_C - T_E}\right)\left(\frac{T_G - T_C}{T_G}\right)$

$$= \left(\frac{273+15}{273+30-273-15}\right)\left(\frac{273+75-273-30}{273+75}\right)$$

$$= \left(\frac{288}{15}\right) \times \left(\frac{45}{348}\right)$$

$$= \frac{285 \times 3}{348} = \frac{864}{348} = 2.48$$

#



COP:- ?

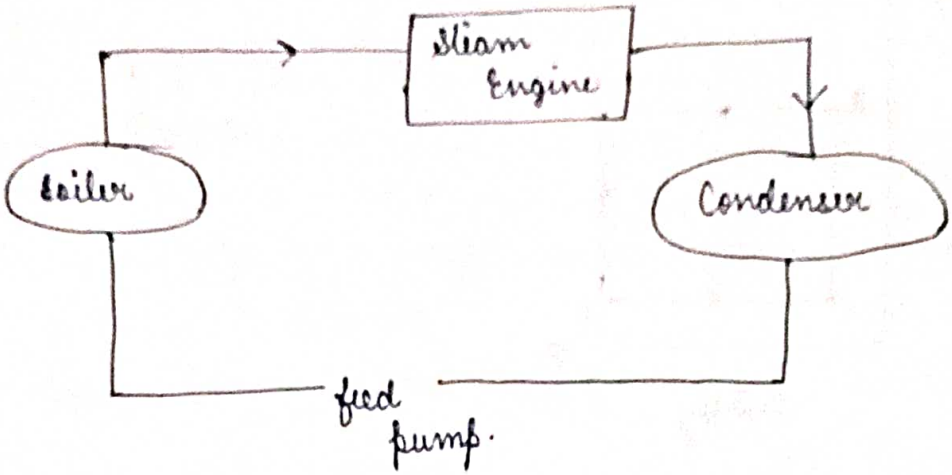
$Q_1 = Q_2 + W_{in}$

$W_{in} = Q_1 - Q_2$

Sol:- $\frac{\text{Desired effect}}{\text{Winput}}$ $\therefore COP = \frac{Q_2}{W_{in}} =$

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

• Steam Engine:-



Δ Steam power plant.

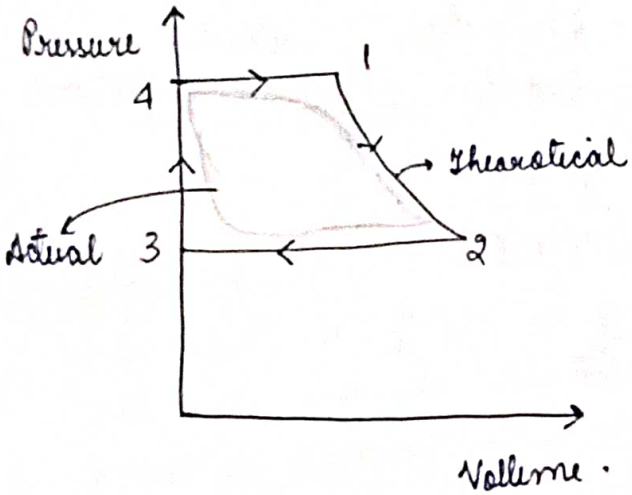
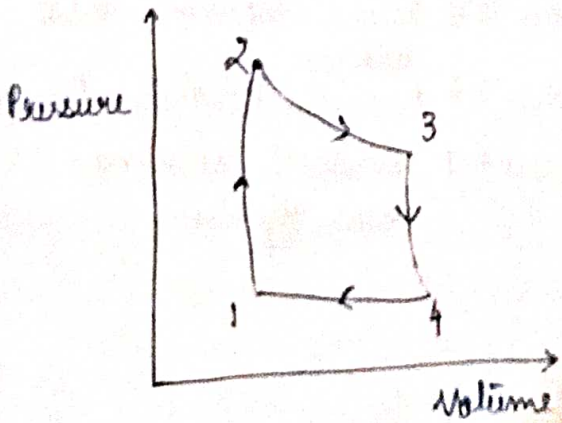
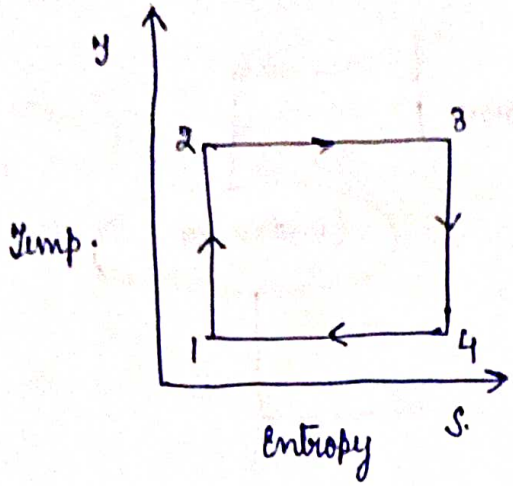


Diagram fraction = $\frac{\text{Actual area in diagram}}{\text{Theoretical area in diagram}}$.

• Carnot's cycle:-(Hypothetical Cycle)



process 1-2 Reversible adiabatic compression
process 2-3 Irreversible thermal expansion
process 3-4 Iso adiabatic expansion
process 4-1 Reversible isothermal
entropy.



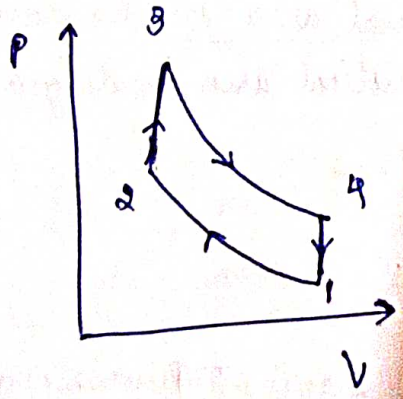
Efficiency of Carnot's cycle = $\eta = \frac{Q_{addition} - Q_{reduction}}{Q_{addition}}$

$\eta = 1 - \frac{Q_{reduction}}{Q_{addition}}$ (reduction = = rejection)

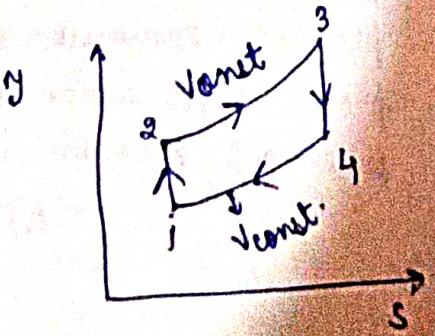
$1 - \frac{m C_p T_1}{m C_p T_2}$

$1 - \frac{T_1}{T_2}$; $T_2 > T_1$

. Otto cycle (Petrol Engine)



process 1-2 Reversible adiabatic comp.
process 2-3 Constant volume heat addition
process 3-4 Reversible adiabatic expans
process 4-1 Constant volume heat rejection

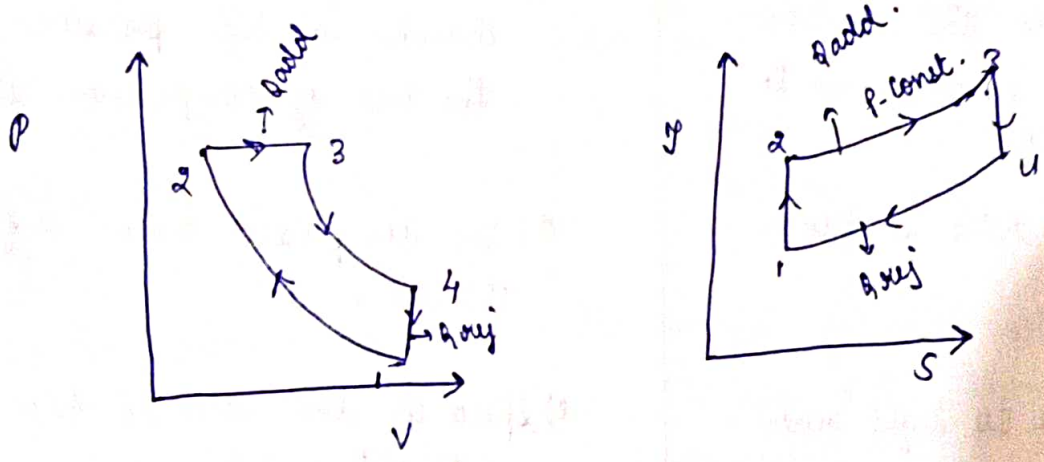


$$\eta = \frac{Q_{addition} - Q_{rejection}}{Q_{addition}}$$

$$\eta = 1 - \frac{Q_{rejection}}{Q_{addition}}$$

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

- Diesel Cycle:- (Constant procus cycle)



procus 1-2 Adiabatic compression
procus 2-3 Constant volume heat addition
procuss 3-4 Reversible adiabatic expansion
procus 4-1 Constant volume heat rejection

$$\eta = \frac{W_{net}}{Q_{supply}}$$

$$\eta = \frac{Q_{add} - Q_{rej}}{Q_{add}}$$

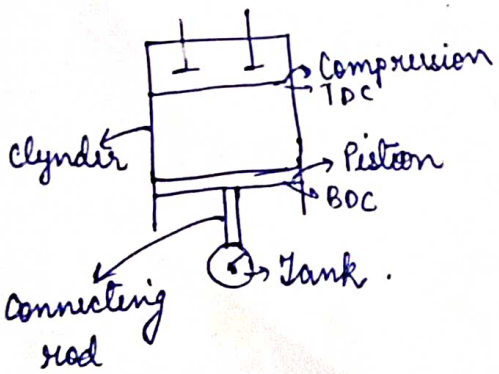
$$\eta = 1 - \frac{Q_{rej}}{Q_{add}}$$

$$\eta = 1 - \frac{1}{\gamma(r_c)^{\gamma-1}}$$

• Comparison between otto and Diesel cycle

Otto cycle (SI engine)	Diesel cycle. (CI engine)
a) Base ground otto cycle	a) Base ground diesel cycle
b) Petrol used as a fule, have high self ignition temperature.	b) Diesel is used a fuel, have low self ignition temperature.
c) Fuel and air in produce as a gaseous mixture in the suction store. Carboretor is necessary to provide the mixture	c) Fuel is injected in the combustion chamber at high pressure at the end of compression stroke
d) The compression ratio is from 6 to 12.	d) The compresion ratio is from 15 to 22.
e) Speed is high due to light weare.	e) Speed is low dues to heavy weight.
f) The maximum efficiency of SI engine is low due to low compression ratio.	f) The efficiency is high due to high compresion ratio

• Four stroke engine :-



a) Suction stroke
b) Compression
c) Expansion (Power).
d) Exhaust stroke.

Two stroke cycle

a) The cycle is completed in strokes of piston or in one revolution of crank shop. Thus one power stroke is obtained in each revolution of crank shopt.

b) Because of above turning moment is uniform and hince lighter fly wheel is required.

c) Two stroke engine no valve is required. But only port is required.

d) Thermal efficiency lower, part load efficiency lesser than four stroke cycle engine. In 2 stroke petrol engine some fuel is exhausted during scavenging.

e) Volumetric efficiency is less due to lesser time of the induction.

f)

Four stroke cycle:-

a) The cycle is completed in four strokes of piston or in two revolution of crank shaft. Thus one power stroke is obtained in every two revolution of crank shaft.

b) Because of above turning moment is not uniform and hence heavier fly wheel is needed.

c) This engine contain valve and valve mechanism.

d) Thermal efficiency higher, part load efficiency better than two stroke cycle engine.

e) Volumetric efficiency is more due to greater typ time of induction

f) Because of one power stroke in two revolution power produce for same size of engine is small or for the same power of engine is heavy and bulky.