E-CONTENTS
OF
THERMO DYNAMICS-II

NAME : HITESH AGGARWAL

DESIGNATION : LECTURER (MECH. ENGG.)

SUBJECT : THERMODYNAMICS-II

BRANCH : MECH. ENGG.

SEMESTER : 4TH (2ND YEAR)

CHAPTER-1

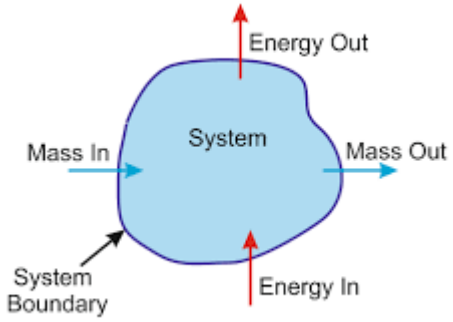
INTRODUCTION:- The field of science dealing with energy in the form of heat and work and their conversion into each other.

1.1 MACROSCOPIC ANALYSIS:- The description of a system using a few measurable properties is knows as Macroscopic analysis of the system.

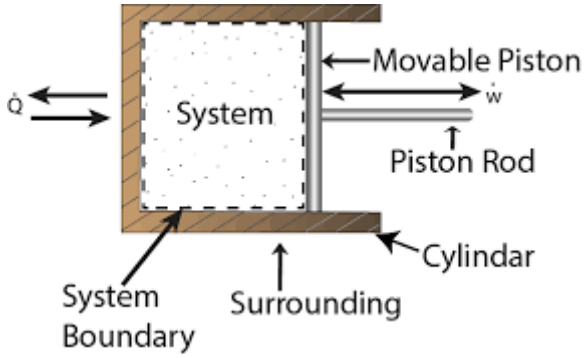
1.2 MICROSCOPIC ANALYSIS:- The study on the basis of behaviour of individual atom and molecules of the substance then the study is said to be Microscopic analysis.

1.3 Types of thermo dynamic system:-

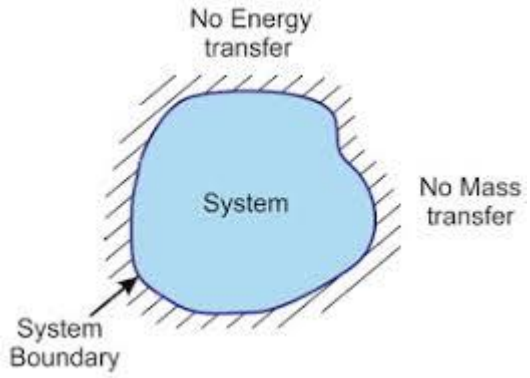
Open system:-If there is an exchange of mass across the system boundary.



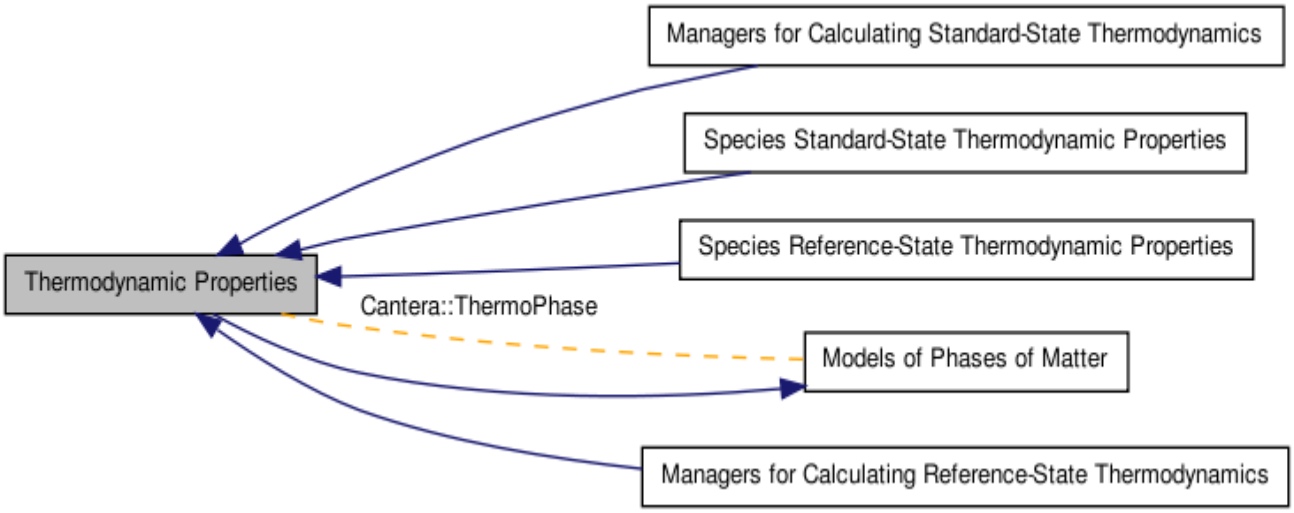
Closed system:-If there is no transfer of mass across the system of the boundary.



1.3.1 Isolated system:- If there is no transfer of mass and energy to and from the system.



1.4 THERMO DYNAMIC PROPERTY:- A thermo dynamic property refer to certain observable quantities which can be used to describe the condition or state of the system.

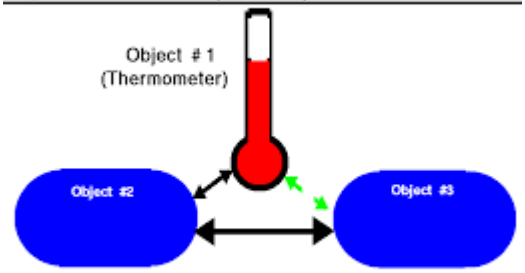


1.5 THERMO DYNAMIC EQUILIBRIUM:- A state of thermo dynamic equilibrium is said to be in a system if no change in any macroscopic properties is registered and the system is assumed to be isolated from its surrounding.

Thermodynamic Equilibrium

(Zeroth Law)

Glenn Research Center



When two objects are separately in thermodynamic equilibrium with a third object, they are in equilibrium with each other.

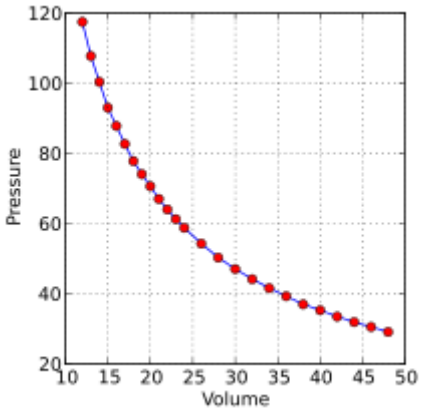
Objects in thermodynamic equilibrium have the same temperature.

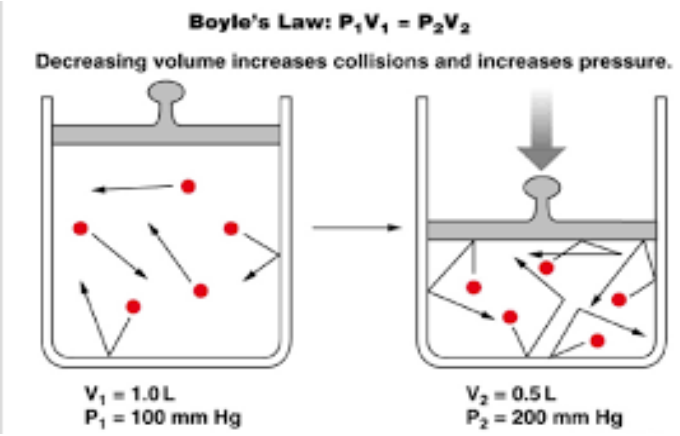
CHAPTER-2

2.1 PERFECT GAS:- A perfect gas or ideal gas may be defined as a state of a substance whose evaporation from its liquid state is complete.

2.2 BOYLE'S LAWS:-This law states that "the absolute pressure of a given mass of a perfect gas varies inversely as its volume, provided the temperature remains constant''.

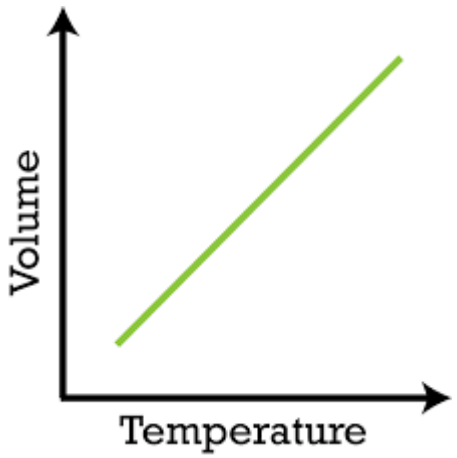
Pα1/V





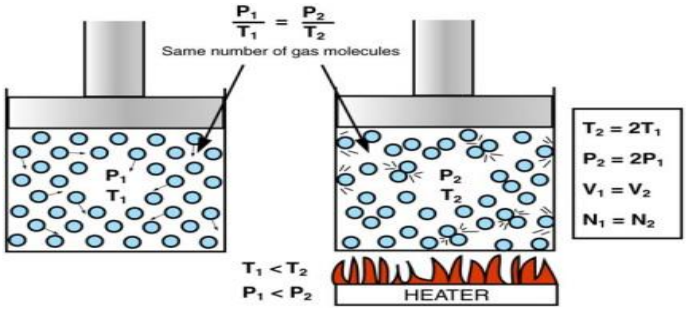
2.3 CHARLE'S LAW:- This law state that "the volume of a given mass of a perfect gas varies directly as its absolute temperature, provided the pressure remains constant".

V α T or V/T= CONSTANT

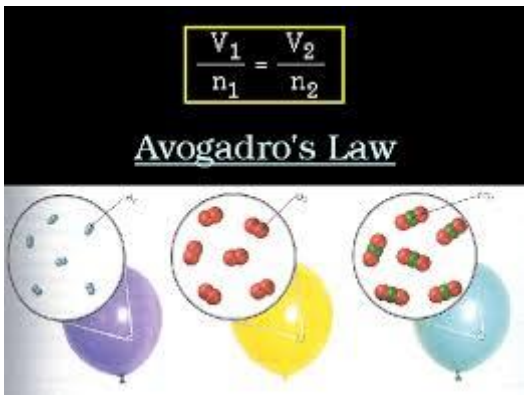


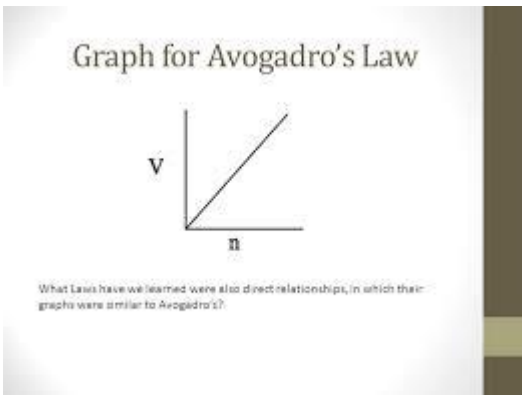
2.4 GAY-LUSSAC LAW:-This law states that "the absolute pressure of the given mass of a perfect gas varies directly as its absolute temperature, provided the volume remains constant".

P α T OR P/T=CONSTANT



2.5 AVOGADRO'S LAWS:- This law states that "equal volume of all gasses will have equal number of Molecules under identical conditions of temperature and pressure".

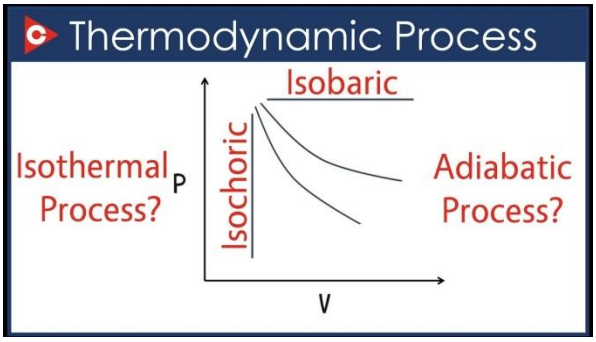




2.6 REGNAULT'S LAWS:- This law states that "the two specific heat C_p(specific heat at constant pressure) and C_v (specific heat at constant volume) of a gas do not change with the change of temperature and pressure.

CHAPTER-3

3.1 THERMO DYNAMIC PROCESS:-The continuous series of states followed by the working medium has it liberates, transforms or receives energy is knows as thermo dynamic process.



3.1.1 TYPES OF THERMO DYNAMICS PROCESSES:-

The important thermo dynamics process are:-

1.3.1.1 REVERSIBLE NON FLOW PROCESS:-

1. **Constant volume process**
2. **Constant pressure process**

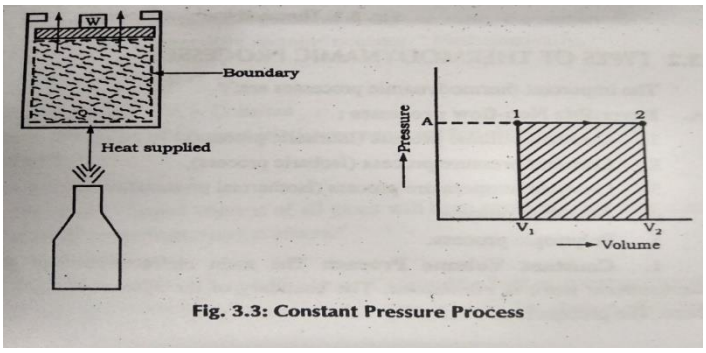


Fig. 3.3: Constant Pressure Process

3. **Constant temperature process**

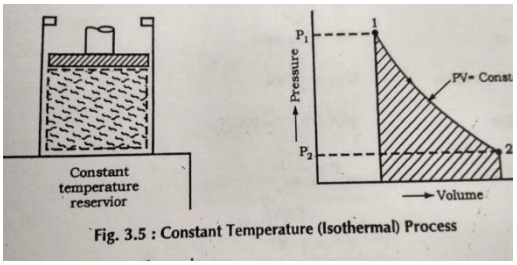


Fig. 3.5 : Constant Temperature (Isothermal) Process

4. **Adiabatic process**
5. **Polytropic process**

1.3.2 IRREVISIBLE NON-FLOW PROCESSES

3.2 THROTTLING PROCESS:- Throttling process is irreversible steady flow expansion process in which a perfect gas is expand through an orifice of very minute dimensions or slightly open valve.

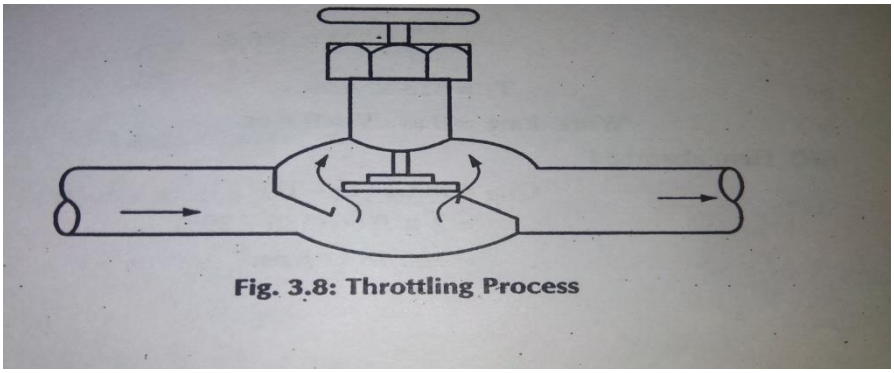


Fig. 3.8: Throttling Process

3.3 HYPERBOLIC PROCESS:- The process in which the gas is heated or expanded in such a way that the product of its pressure and volume remains constant is known as Hyperbolic process.

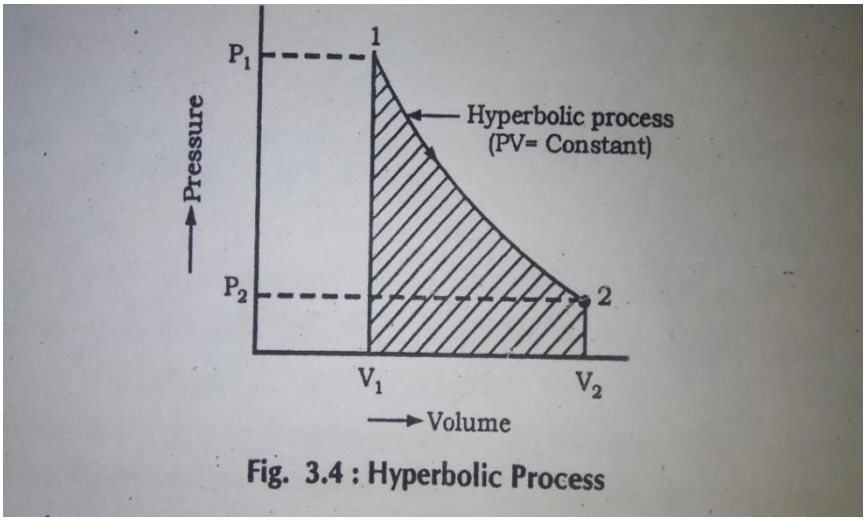


Fig. 3.4 : Hyperbolic Process

3.4 ADIABATIC PROCESS:- The process during which work is done and no heat is transfer across the system boundary is known as Adiabatic process.

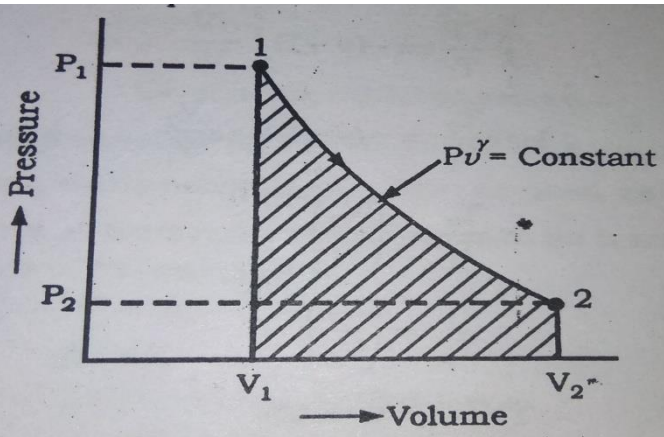


Fig. 3.6 : Adiabatic Process

CHAPTER-4

4.1 LAWS OF CONSERVATION OF ENERGY:- This law states that "the energy can neither created nor be destroyed through it can be transfer from one form to another form" and which the energy can exist.

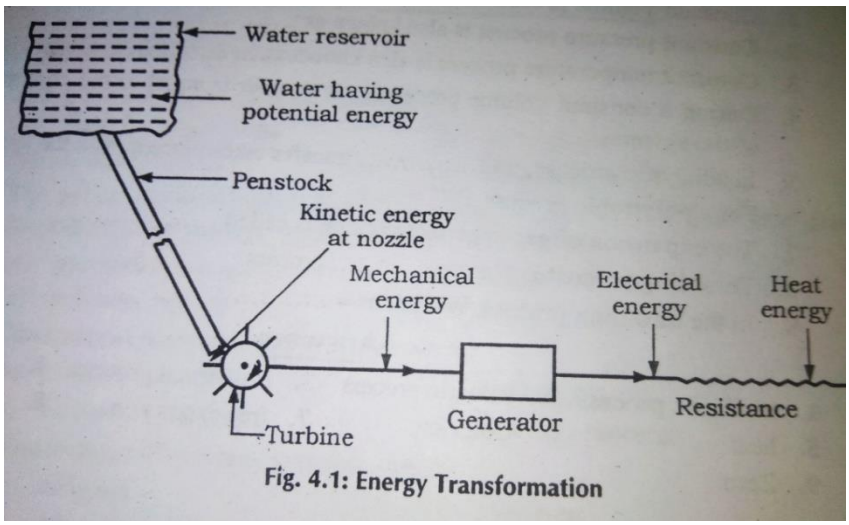


Fig. 4.1: Energy Transformation

4.1.1 FIRST LAW OF THREMO DYNAMICS:-(FOR CLOSED SUSTEM UNDER GOING A CYCLE):-

A process is cyclic if the initial and final state of the system are identical. Energy which enters a system as heat may leave the system as work, or energy which enters the system as work may leave as heat.

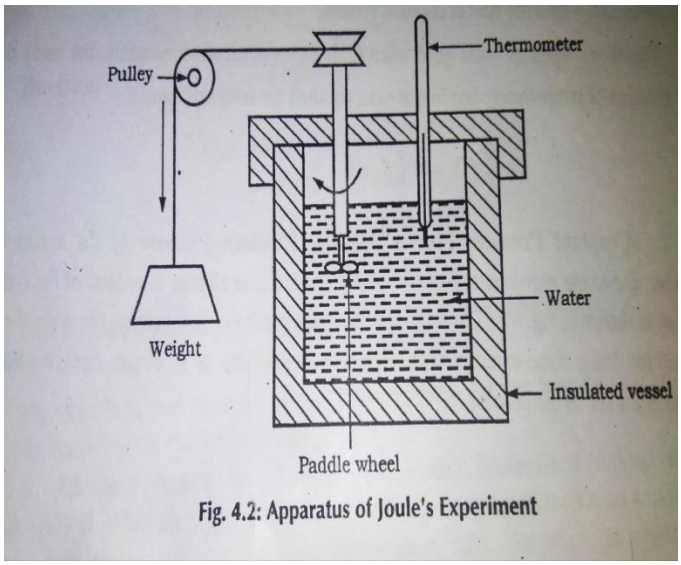


Fig. 4.2: Apparatus of Joule's Experiment

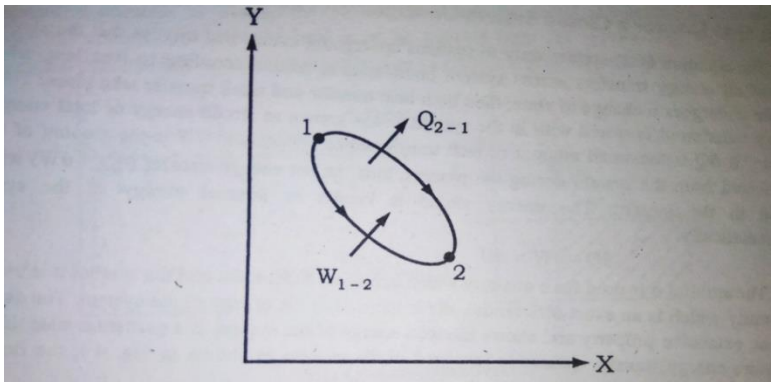


Fig. 4.3: Work Transfer (W_{1-2}) and Heat Transfer (Q_{2-1}) in a Closed Cycle

$$(\Sigma W)_{cycle} \propto (\Sigma Q)_{cycle}$$

or $$(\Sigma W)_{cycle} = J(\Sigma Q)_{cycle}$$

where J is the Joule's equivalent. This is also expressed in the form

$$\oint \delta W = T \oint \delta Q$$

4.2 NON- FLOW PROCESS:- In this process the working substance remains in a closed system, but heat and work may cross the boundary of the system. Non-flow process may be reversible or irreversible.

4.3 ISOTHERMAL PROCESS:- A process at a constant temperature is called an Isothermal process. When a working substance in a cylinder expands from a high pressure to low pressure, temperature falls. There fore, in order to keep the temperature constant in isothermal processs, heat must be added continuously.

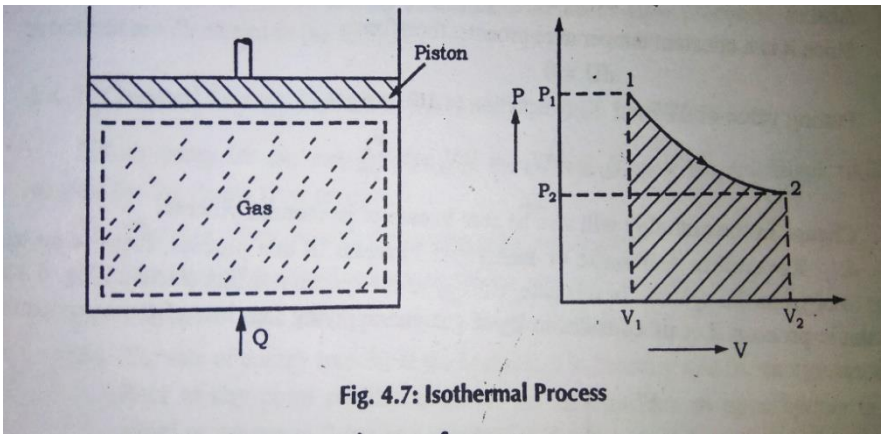


Fig. 4.7: Isothermal Process

4.4 CARNOT ENGINE:- There are following assumption are made in the Carnot engine

i) The wall of the cylinder and piston are perfect of non conductor of heat.

ii) In the cylinder piston motion should be friction less.

iii) Working medium is a perfect gas having constant specific heat.
iv) It can irreversible.
v)

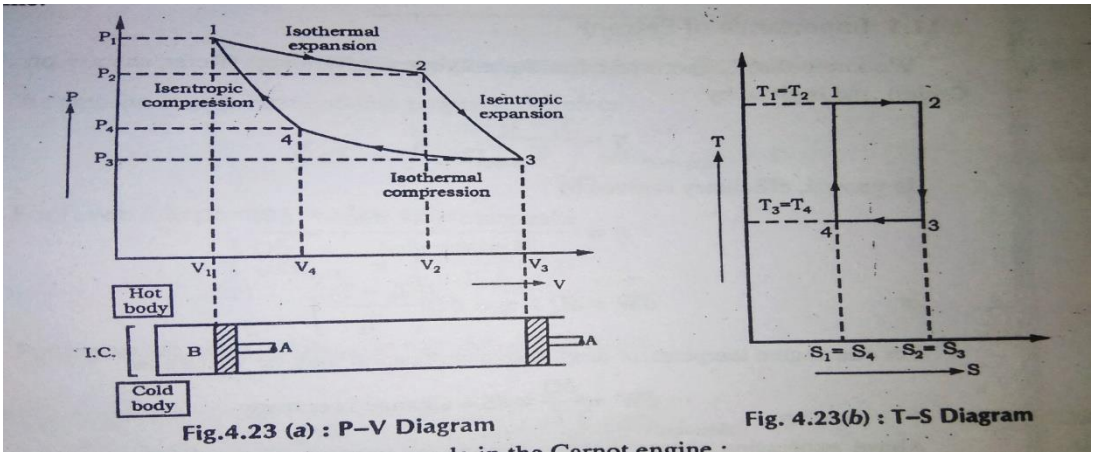


Fig.4.23 (*a*) : P–V Diagram

Fig. 4.23(*b*) : T–S Diagram

CHAPTER-5

5.1 IDEAL GAS :-A hypothetical gas which obey the laws of Pv=RT at all temperature and pressure is known as ideal gas.

5.2 REAL GAS :- The real gas do not obey the gas law strictly and there equation of stat is not exactly the same as that of perfect gas.

5.2.1.1 TRIPLE POINT:- The triple point may be defined as the point at which all the three phases solid, liquid and vapour coexist in equilibrium.

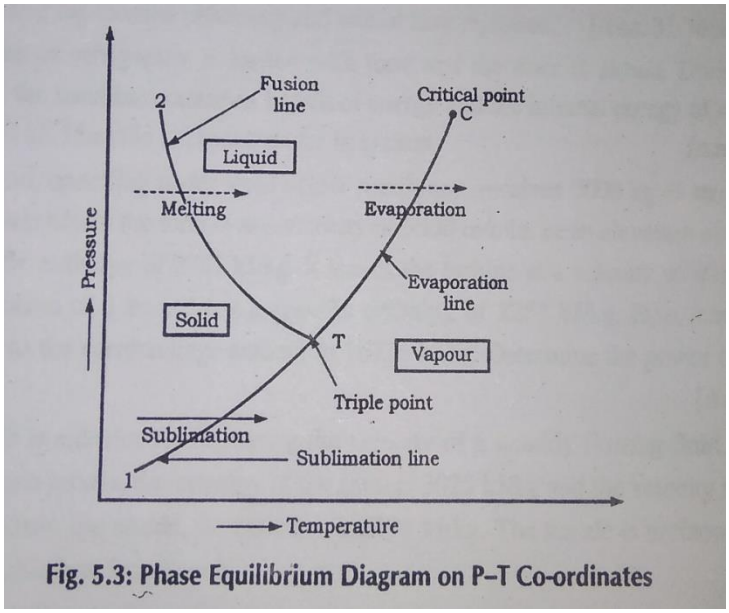
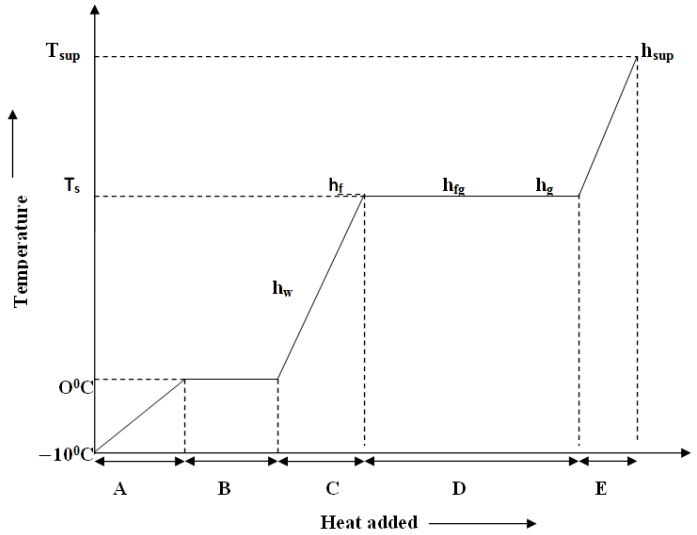


Fig. 5.3: Phase Equilibrium Diagram on P–T Co-ordinates

CHAPTER-6

6.1 WET STEAM:- When the steam contain moisture or particals of water in suspention it is said to be Wet steam.

6.2 FORMATION OF STEAM:- In general, steam can be formed by boiling water in a vessel. But to use it effectively as a working or heating medium, it has to produce in a closed vessel under pressure. Steam formed at a higher pressure has higher temperature and can be made to flow easily through insulated pipes from steam generator to point of use. A simple arrangement of formation of steam at constant pressure is shown in Fig.



A = Sensible Heat taken by Ice

B= Latent Heat of Fusion

C = Sensible Heat taken by Water

D = Latent Heat of evaporation

E = Sensible Heat taken by Steam

h_w = Specific enthalpy of water

h_f = Specific enthalpy of saturated water

h_{fg} = Latent heat of evaporation

h_g = Specific enthalpy of dry saturated steam

h_{sup} = Specific enthalpy of super heated steam

Fig. Temperature enthalpy curve of formation of steam at constant pressure

6.3 DRY SATURATED STEAM:- When the wet steam is further heated and it does not contain any suspended particals of water is known as Dry saturated steam.

6.4 SUPER HEATED STEAM:- When the dry steam is further heated at a constant pressure thus rising its temperature is said to be Super heated steam.

6.5 ENTHALPY OF STEAM:- It is the amount of heat absorbed by water from freezing point to saturation temperature plus the heat absorbed during evaporation.

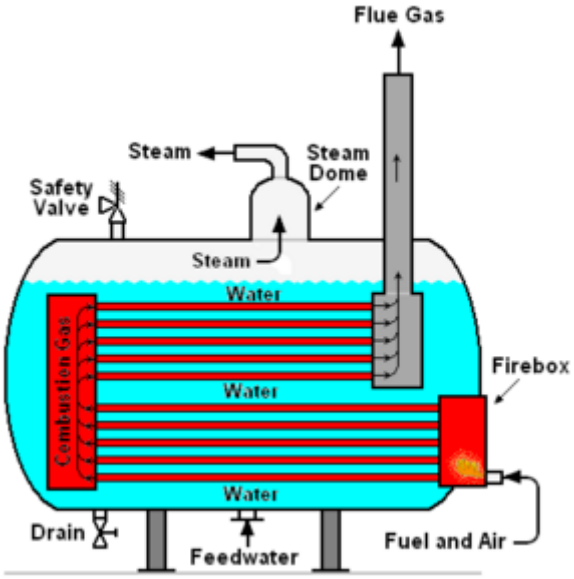
6.6 LATENT HEAT OF STEAM:- It is defined as the quantity of heat required to convert one KG of water at its boiling point into dry saturated steam at the same pressure.

6.6.1 **INTERNAL ENERGY OF STEAM:-** The actual heat energy stored in the steam above the freezing point of water is known as Internal energy of steam.

6.6.2 **SPECIFIC VOLUME OF STEAM:-** It is the volume occupied by the steam per unit mass at a given temperature and pressure.

CHAPTER -7

7.1 STEAM GENERATOR:-A steam generator or boiler is usually a closed vessel made of steel whose function is to transfer the heat produced by the combustion of fuel to water and ultimately to generate steam.



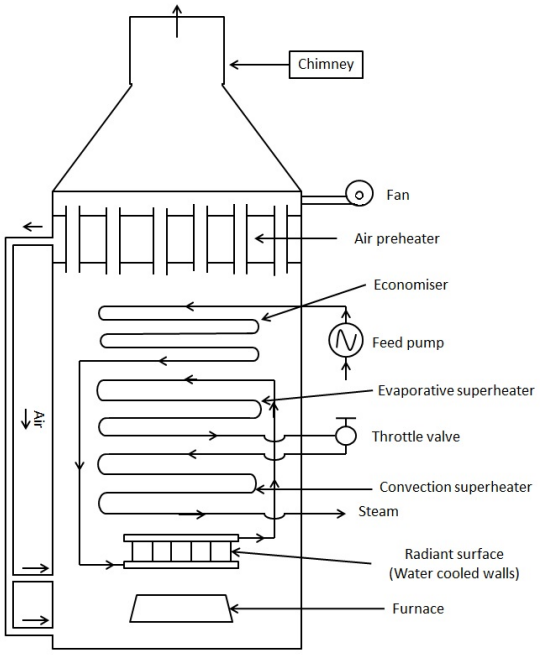
7.2 CLLASIFICATION OF BOILER:-There are various way in which boiler may be classified which are below-

- **ACCORDING TO THE CONTENTS IN TUBES:** The steam boiler according to the contents in the tube may be classified as
  a. Fire tube boiler
  b. Water tube boiler
- **ACCORDING TO THE POSITION OF THE FURNANCE**
  a. EXTERNALY FIRE BOILER
  b. INTERNALY FIRE BOILER
- **. ACCORDING TO THE AXIS OF THE SHELL**
  a. VERTICAL BOILER
  b. HORIZONTAL BOILER
  c. INCLINED BOILER
- **ACCORDING TO THE NUMBER OF TUBE**
  a. SINGLE TUBE BOILER
  b. MULTY BLUR BOILER
- **ACCORDING TO USE**
  a. STATIONARY BOILER
  b. MOBILE BOILER

- **ACCORDING TO THE METHOD OF CERCULATION OF WATER AND STEAM**
  a. NATURAL CIRCULATION BOILER
  b. FORCED CIRCULATION BOILER

7.4 BENSON BOILER

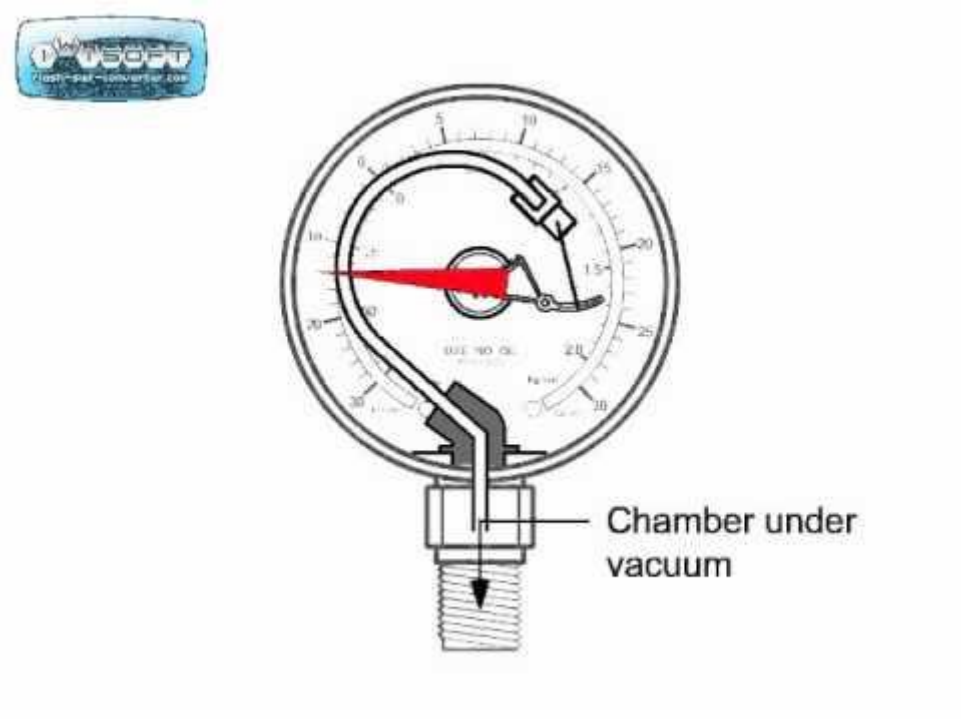
The presence of steam bubbles in contact with the surface of tubes seriously reduces heat transmission from the flue gasses to water. The release of the bubbles also causes water circulation to pulsate which in turn tend to initiate priming.



Benson Boiler

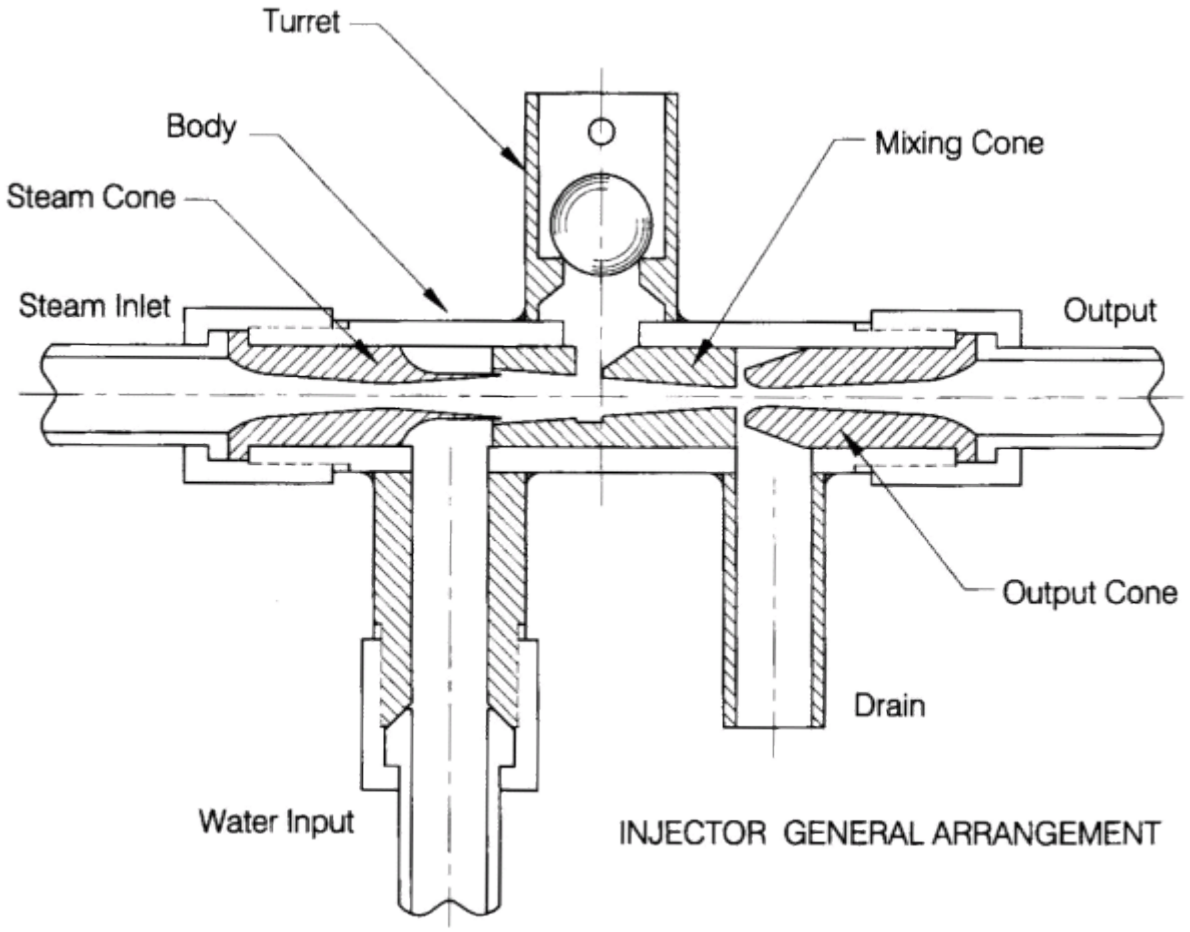
7.5 PRESSURE GAUGE:-

It is mounted on boiler to show the pressure of the steam. Its dial is graduated to read the pressure. BOURDEN'S pressure gauge is commonly used. The essential element of this gauge is elliptical spring tube made of phosphorus and bronze. One end of this tube is closed by a plug while the other end is secured firmly to a hollow block which forms passage for the steam.



When pressure is applied to the interior of the elliptical tube, it tries to assume a circular shape and causes the pointer to move and thus show the pressure on the graduated dial. It should be noted that this pressure gauge show the pressure difference between the steam and atmosphere and in order to have absolute pressure, the atmospheric pressure has to be added to the pressure value shown by the gauge.

7.5.1.1 **STEAM INJECTOR :-** In the steam injector the steam enters the steam chamber whose outlet is in the form of converging nozzle. Where steam gain velocity at the expanse of pressure and then mixes with water in the mixing chamber. In the mixing chamber the steam gets condensed and hence a vacuum is created. Due to this vacuum more water is drawn in the mixing chamber from the feed water tank. From the mixing chamber, the jet of water enters the diversing nozzle where the velocity is again converted into pressure this increases in pressure forces the water into the boiler.



INJECTOR GENERAL ARRANGEMENT

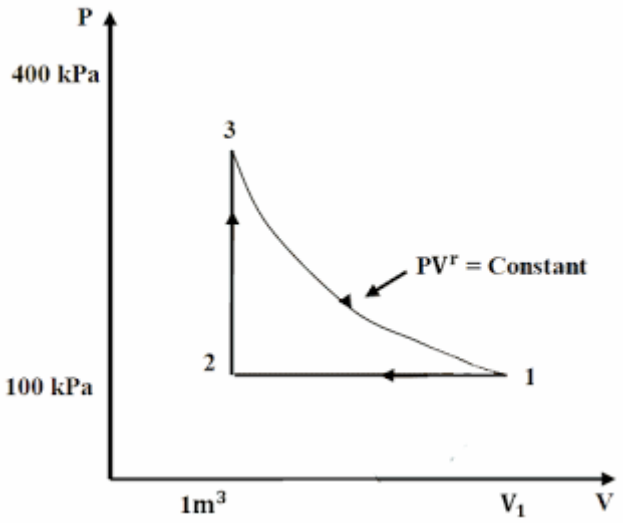
CHAPTER -8

8.1 CYCLE:-A cycle is a series of thermo dynamic operations which occur in a certain order an initial conditions are restored at the end. The cycle may be imaginary or actual. An imaginary cycle may also be called as an ideal cycle.

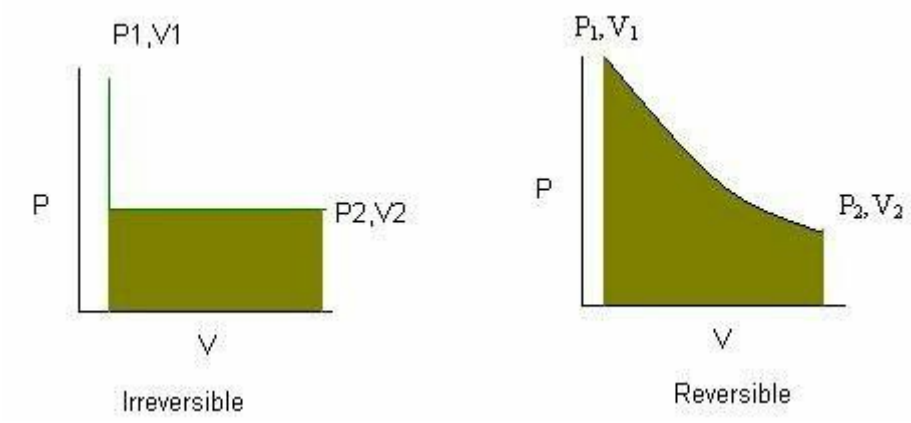
8.2 AIR STANDARD EFFICIENCY:- A thermo dynamic cycle using air as the working substance is known as standard cycle and the efficiency of this cycle s known as air standard efficiency . The actual efficiency of the cycle is always less than air standard efficiency.

η relative =actual thermal efficiency/air standard efficiency

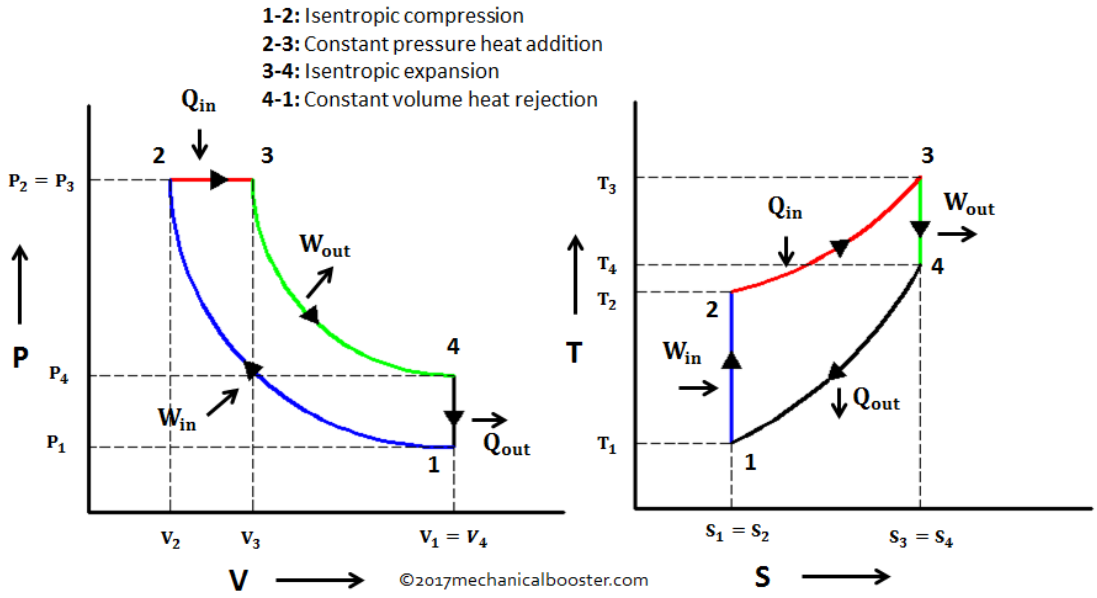
8.3 REVESIBLE PROCESS:- A reversible process (also known as quasi-static process) is one which can be stopped at any stage and can be operated in reverse direction. In other word it may also be defined as the process which can re trace the same path in the reverse direction so as to bring back the original condition.



8.4 **IREVERSIBLE PROCESS:-** An irreversible process is that process in which process can not be repeated exactly in the reverse direction. E.g :- throttling, heat transfer, free expansion, combustion diffusion etc.

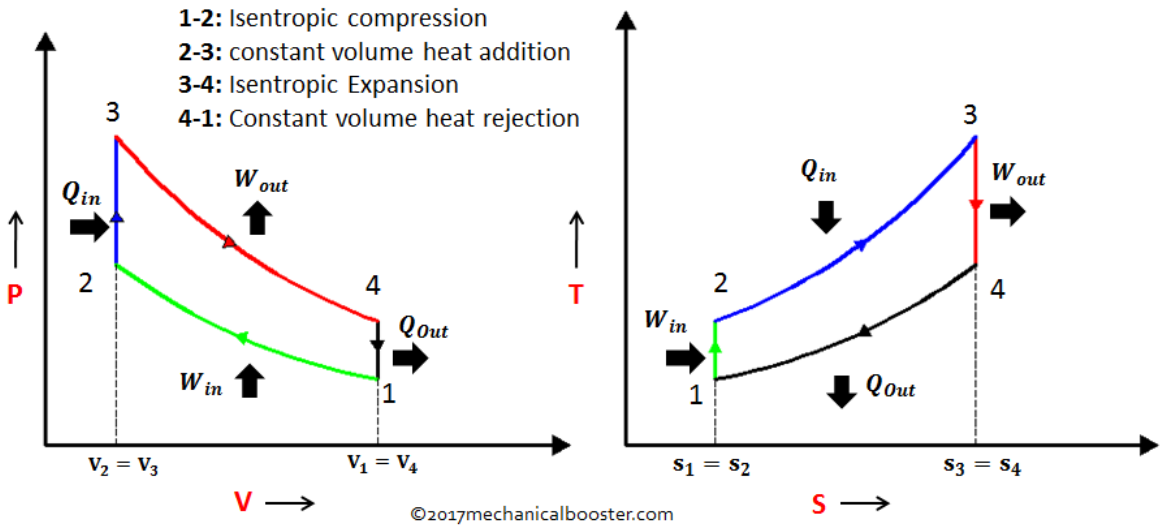


8.5 **DIESEL OF CONSTANT PRESSURE CYCLE:-** It defers from Otto cycle in the respect that heat is supplied constant pressure instead of constant volume. This is an important cycle on which the diesel engine work.



P-V and T-S Diagram of Diesel Cycle

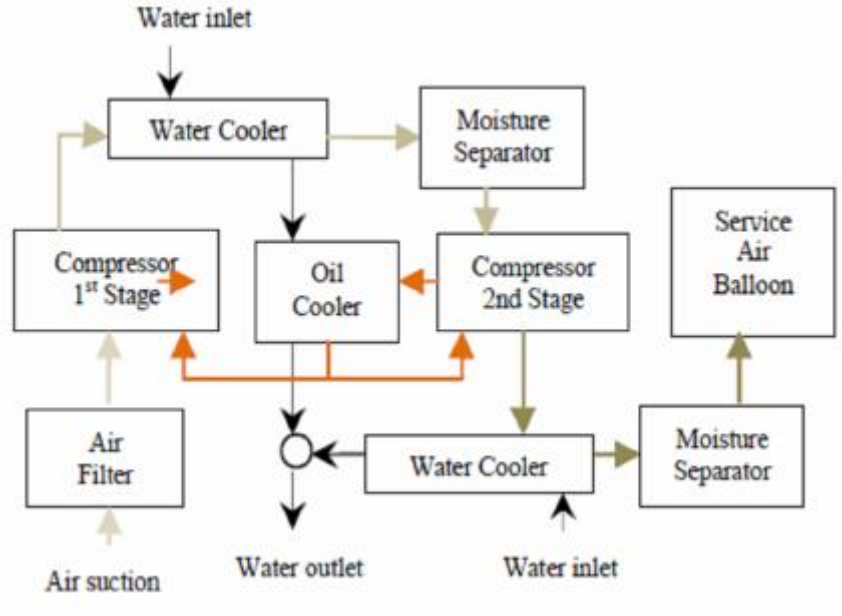
8.6 **OTTO CYCLE OR CONSTAT VOLUME CYCLE:-** The first successful engine working on OTTO CYCLE was build by A.OTTO . It is also known as constant volume cycle, as heat is received and rejected at the constant volume. This cycle is basically used as a standard of comparison for internal combustion engine. The OTTO cycle consist of two constant volume and two reversible adiabatic or isentropic process. Air is used as a working substance for different operation in this cycle.



P-V and T-S Diagram of Otto Cycle

CHAPTER-9

9.1 AIR COMPRESSORS:- An air compressor is a device which compresses the air and rises its temperature. The compressor sucks air from the atmosphere, compresses it and delivers the compressed and a air to a storage vessel.

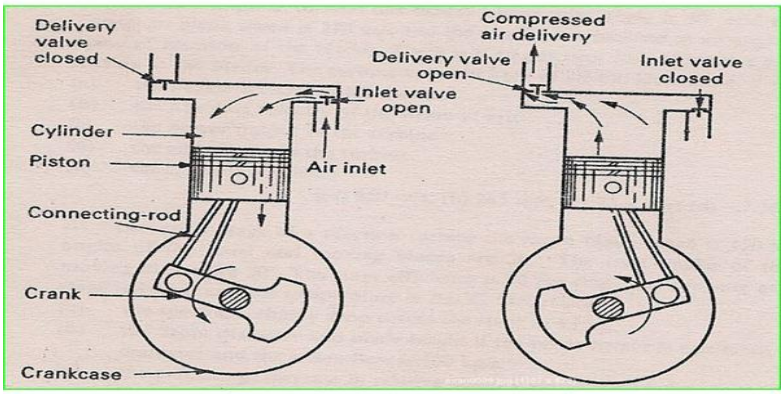


9.2 USES OF COMPRESSED AIR:- Compressed air is used in the following area

a. It is widely used for powering small engine.
b. An excess quantity of air is used in smelting of different metals such as smelting iron and cupola work.
c. It is used for producing blast of air in the blast furnace.
d. It is used in the operation of lifts, pumps.
e. It is used in operating tools in factories.
f. It is used in operating drills and in hammering operations.

9.3 SINGLE STAGE RECIPROCATING AIR COMPRESSOR:- A single stage reciprocating air compressor consist of a cylinder, piston inlet and discharge valves. During this operation, fly wheel gives the turning

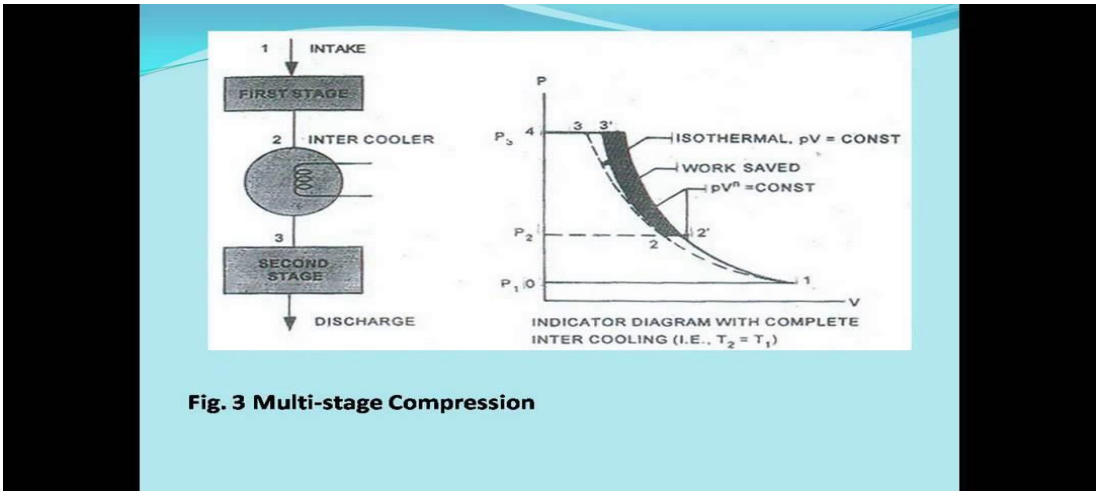
movement to main shaft which is connected to piston through crank shaft



and connecting rod.

9.4 MULTY STAGE COMPRESSION:- In case of single stage reciprocating air compressor, suction , compression and delivery of air take placed in a single stage. But sometimes, the air is required at higher pressure. For this, we can either employ a large pressure ratio in single cylinder the air in two or more cylinders in series.

9.5 INTERCOOLER:- The intercooler is commonly used between two stage with the object of removing heat of compressed air. The cooling water passes through the tubes which are tightly held between two tube plates and the circulation of air over tube is done with the help of baffles.



9.7 TYPES OF ROTATARY COMPRESSIOR:- There are two types of rotary compressor:

1. ROOT BLOWER COMPRESOR
2. VANE BLOWER COMPRESSOR

9.7.1 **Root blower compressor** :- A Root blower compressor consist of two rotors with lobes rotating in opposite direction in an air tight casing which has inlet and outlets ports. The lobes of the rotors are cycloidal or involute from because this insures correct mating between lobes.

9.7.2 **Vane blower compressor**:- A Vane type compressor consist of a rotor or disk rotating eccentrically in an air tight casing with inlet and outlet ports the disk has a number of slots containing vanes which are made of non metallic material usually fibre or carbon.