ENGINEERING THERMODYNAMICS

Chapter-1 Basic Concepts

* **Introduction :-**

The word thermodynamics is made up from two Greek words

(i) Thermo → hot or heat

(ii) Dynamics → power or powerful

→ Thermodynamic can be defined as the science of energy. It deals with the most basic processes occuring in nature. One of the most fundamental laws of nature is the conservation of energy principle.

→ It simply states that during an interaction, energy can change from one form to another but the total amount of energy remains constant.

→ Again thermodynamics may be defined as

It is law of science which deals with the relation among heat, work and properties of system which are in equilibrium.

* **Microscopic and macroscopic point of view**

We know that substance (matter) consists of a Large number of particles called molecules. The properties of the substance naturally depend on the behaviour of these particles.

Microscopic approach	Macroscopic approach
1) Micro mean small	1) Macro mean total or big
2) This approach to Thermodynamics is concerned with individual behaviour of molecule	2) This approach to Thermodynamic is concerned with overall or gross behaviour of molecule
3) The properties like velo., force, K.E. impulse, etc which describe the molecule cannot be easily measured by instruments.	3) The value of the properties of the system are their avrg. values and it measured by instruments
4) The behaviour of the system is found by using statistical method.	4) The behaviour of the system is found by using simple mathematical formula.

* Thermodynamic system and control volume

- **Thermodynamic system:-** A system is a finite quantity of matter or prescribed region of space chosen for study.
- **Surrounding or environment:-** It is the matter or region outside the system.
- **Boundary:-** It is actual or imaginary envelope enclosing the system that seperates the system from its surrounding. The boundary is contact surface shared by both the system and the surroundings. Mathematically speaking, the boundary has zero thickness.

The boundary may be fixed or it may move, as and when a system containing a gas is compressed or expanded. The boundary may be real or imaginary.

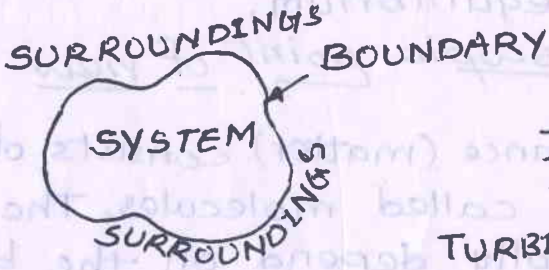


fig-1

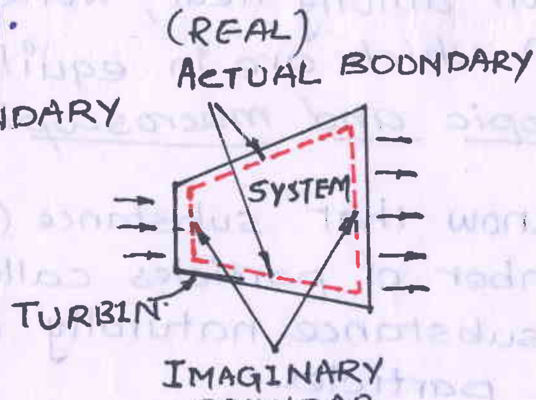


Fig-2

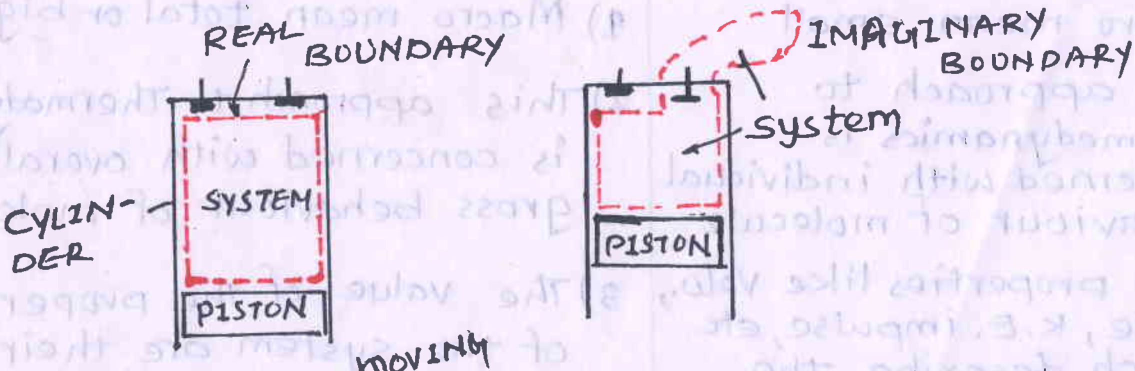
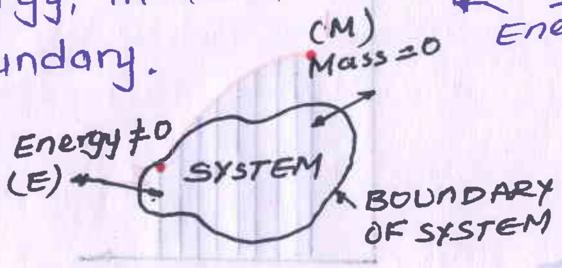
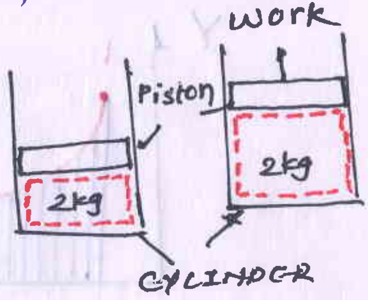


Fig-2 The real and moving IMAGINARY BOUNDARIES

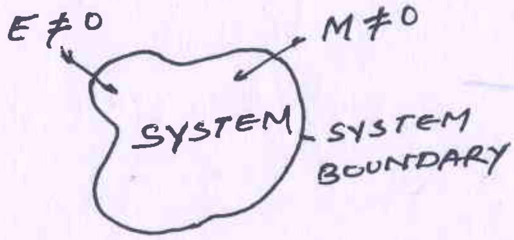
1) Closed system:- In this system no mass transfer across the system boundary. But energy, in form of heat or work, can cross the boundary.





Consider piston-cylinder device, piston moves upward when gas is heated and work is transferred in form of piston movement. But there is no mass transfer across the boundary. It is also called control Mass system.

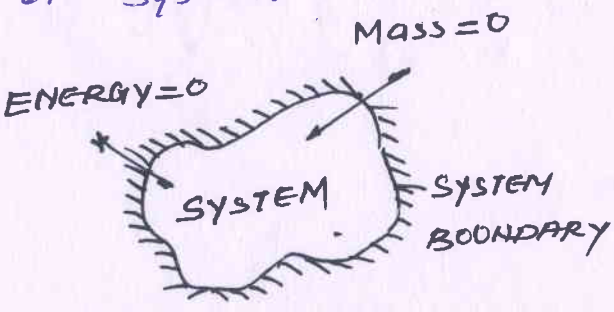
2) Open system:- In this system the mass as well as energy transfer across the boundary of system. Most of engineering device are generally open system. It also is called as control volume system.



Example:- An air compressor, Turbine, Refrigerator

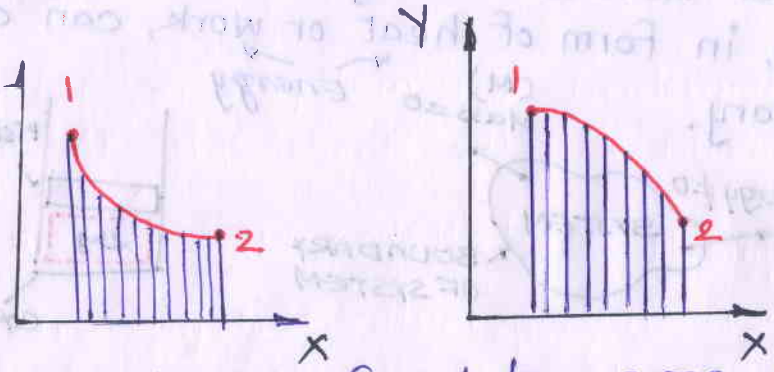
3) Isolated system:- In this system niether mass nor energy transfer across the boundary of system.

Examples: - Thermos flask



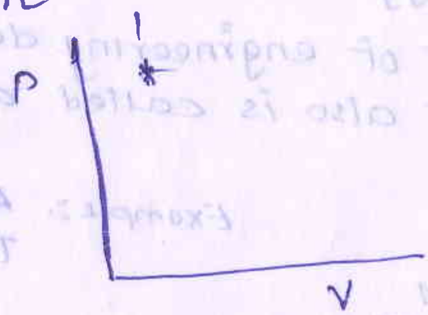
Path function: Their magnitudes depend on the path followed during a process as well as the end states.

example: Heat(Q) and Work(W)



Their magnitudes found by area under the curve

Point fuction: The depend on the state only, and not on how a system reaches that state, All properties are point function; Any properties represent by point in Graph



Homogeneous & Hetrogeneous systems

→ **Homogeneous:-** A system which consists of a single phase is termed as homogeneous system.

Example:- 1) Mixture of air & water vapour
2) water plus nitric acid
3) Octane plus heptane

→ **Heterogeneous system:-** A system which consists of ~~a single~~ two or more phases is called hetrogeneous system.

Example:- 1) water + steam 2) Ice + Water 3) Water + oil

* Thermodynamic properties:

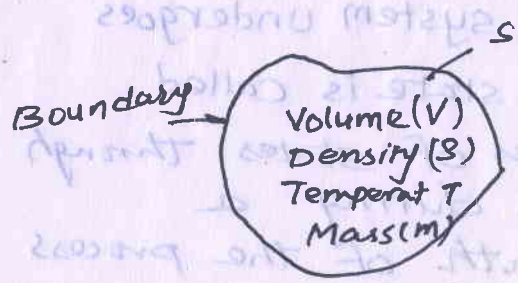
Any characteristic of a system by which its physical condition may be described is called a property. e.g. pressure, volume, Temperature, mass, viscosity etc.

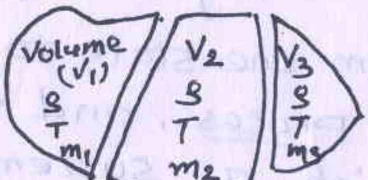
→ **Intensive properties:-** These properties Independent on the mass of the system.

Example:- 1) temperature (T) 2) pressure 3) Density (ρ)

→ **Extensive properties:-** These properties depend on the mass of the system.

Example:- 1) Volume (V) 2) Mass 3) Total Energy





→ **Dependent properties:-** Those are properties which define the state of the system. To completely define the state of the system, a certain minimum number of properties are required to be known These properties refered to as independent properties

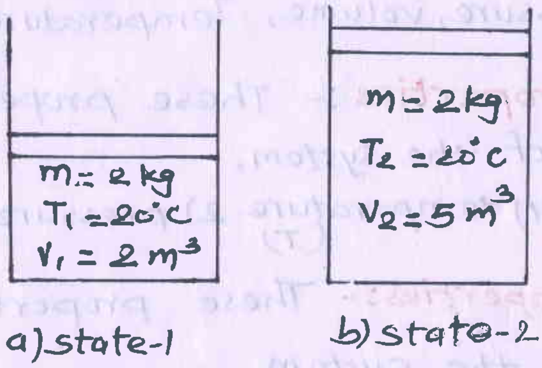
→ **Dependent properties:-** The value of those properties can be determined in terms of values of Independent properties, know as dependent properties

* State, Process and Cycle.

State:- It is the condition of the system at an instant of time as described by its properties. It is each unique condition of a system.

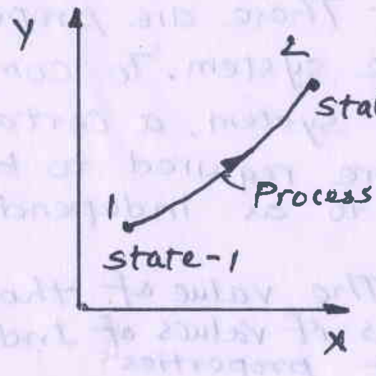
OR

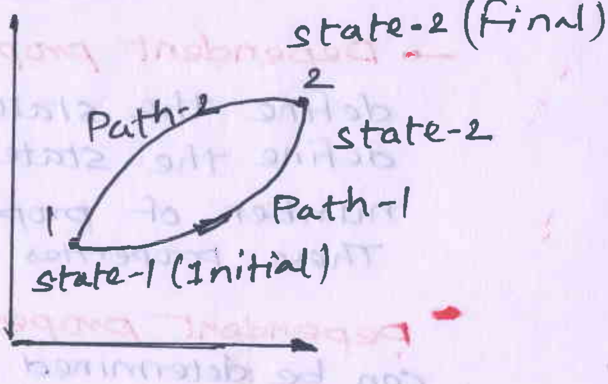
Consider a system not undergoing any change. At this point, all the properties can be measured or calculated throughout the entire system, which give us a set of properties that competely describes the condition, or the state, of the system. At a given state, all the properties of a system have fixed values. If the value of even one property changes, the state will change to different one



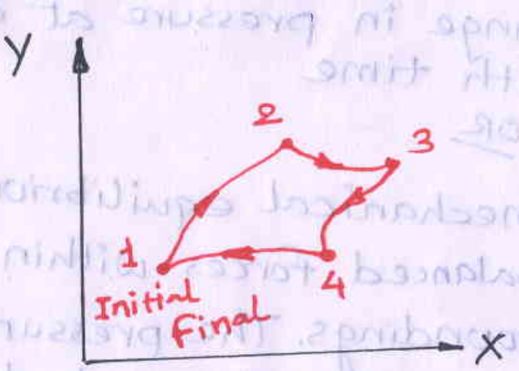
A system at two different states.

Process: Any change that a system undergoes from one state to another state is called a process. and the series of states through which a system passes during a process is called the path of the process





Cycle:- It is defined as serieses of state changes such that the final state is identical with the initial state.



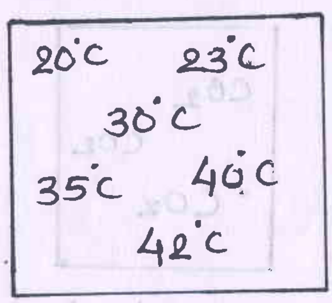
* Thermodynamic Equilibrium

Thermodynamics deals with equilibrium states. The word equilibrium implies a state of balance, In an equilibriom state there are no unbalanced potentials (or driving forces) within the system. A system in equilibriom experiences no changes when it is isolated from its surroundings.

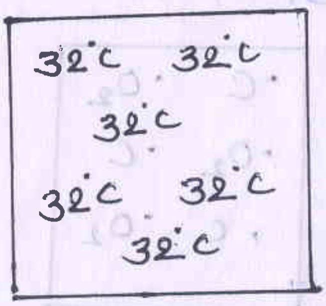
"A system is said to be in a state of thermodynamic equilibriom if the value of properties is the same at all points in the system."

1) Thermal equilibrium:-

If the temperature of the system does not change with time and has same value at all points of the systems, the system said in thermal equilibriom.



No thermal equilibriom



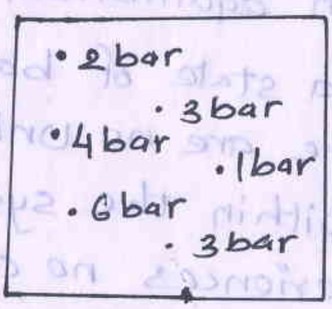
Thermal equilibriom

2) Mechanical Equilibrium :-

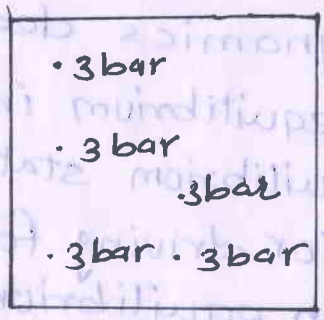
Mechanical Equilibrium is related to pressure, and a system is in mechanical equilibrium if there is no change in pressure at any point of the system with time

OR

A system is in mechanical equilibrium if there are no unbalanced forces within the system or between surroundings. The pressure in the system is same at all points and does not change with respect to time.



No Mechanical equilibrium

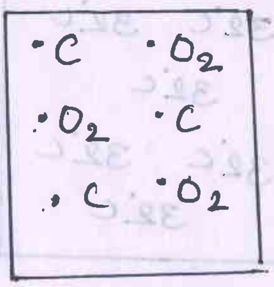


Mechanical equilibrium

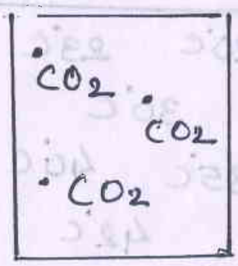
3) chemical equilibrium :-

If its chemical composition does not change with time and no chemical reaction takes place in the system.

When the above condition for any of the three type of equilibrium are not satisfied, a system is said to be in a non-equilibrium state

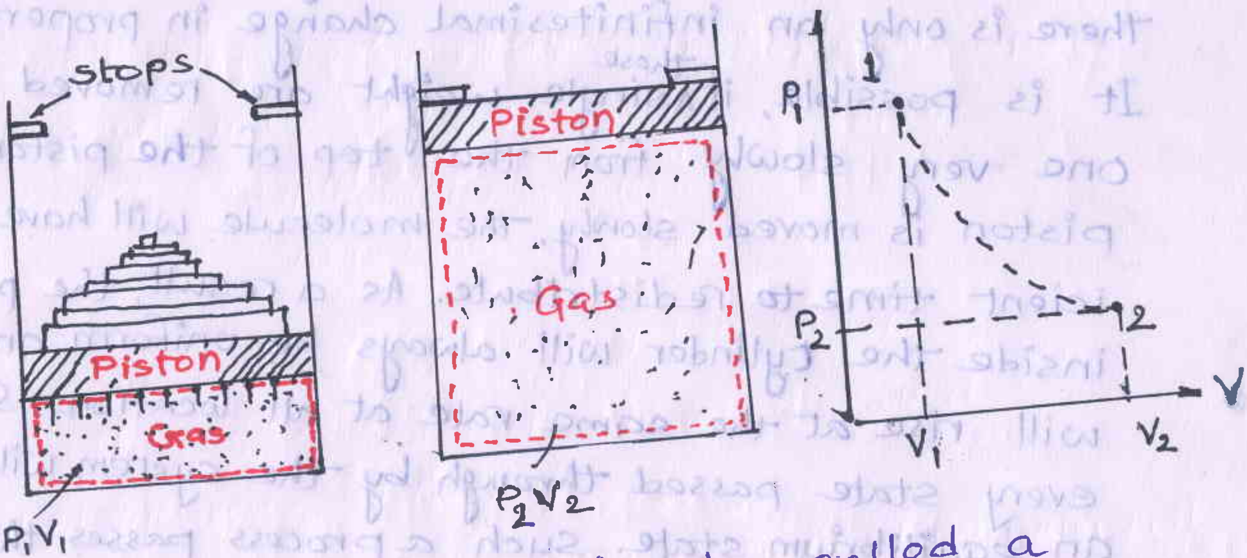


No chemical equilibrium



Chemical equilibrium

* Quasi - static process:-
(Quasi → Almost)



Quasi - static process is also called a reversible process. This process is a succession of equilibrium states and infinite slowness is its characteristic feature.

Let us consider system of gas contained in cylinder as shown in fig. The system initially is in an equilibrium state (P_1V_1), and describ by properties P_1, V_1, T_1. The upward force exerted by Gas on the piston is balanced by weight on the piston. If the weight is removed, there will be an unbalanced forced betn the system and the surroundings. Due to the gas pressure, the piston will move up the stops.. Then system again comes to the equilibrium state which described by the properties P_2, V_2, T_2. But the intermediate states passed through by the system are non-equilibrium and it will not be possible to describe the path

Thus process 1-2 is non-Quasi-static process.
It represent in dotted line on P-V-diagram

If process 1-2 takes place slowly, then each step, there is only an infinitesimal change in properties. It is possible, if these single weight are removed one by one very slowly from the top of the piston. If piston is moved slowly, the molecule will have sufficient time to redistribute. As a result, the pressure inside the cylinder will always be uniform and will rise at the same rate at all locations. So every state passed through by the system will be an equilibrium state. Such a process passes through all the equilibrium points is called Quasi-static process