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Engineering Thermodynamics

Classroom Notes

[Handwritten]

For GATE | ESE | PSU's

Mechanical Engineering

By: Mr. Praveen Kulkarni

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1. Basic Concepts

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Chapter -1

Basic Concepts

Thermodynamics

It is the science of energy transfer and it effects on properties of system.

Energy transfer may be Heat, or work or both heat and work.

→ The main aim of thermodynamic study is to convert dis-organised form of energy (Heat) into organised form of energy (work) in an efficient Manner.

Applications of Thermodynamics:

Refrigeration, Air-conditioning, steam power plant, I.C. engines etc.

BASIC CONCEPTS

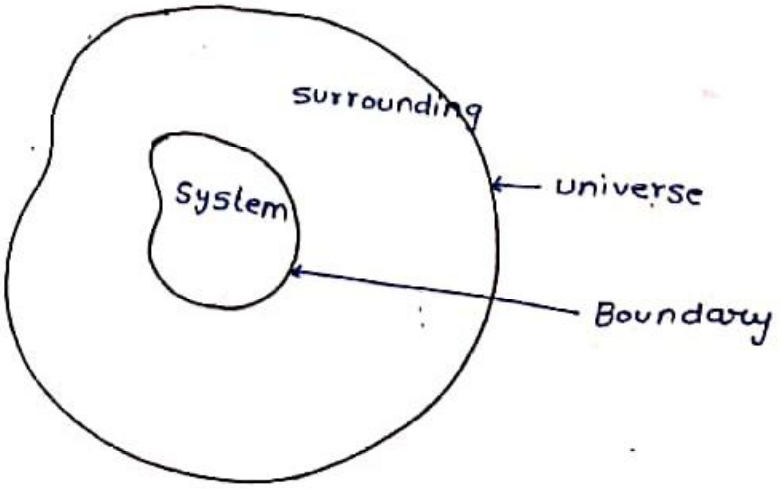
System:-

It is a region in space upon which the study is focused or concentrated.

Surroundings:

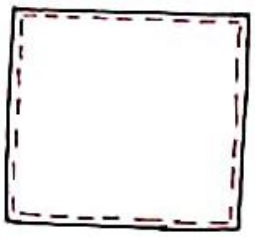
Any thing external to the System, where the effect of system is felt, is known as surrounding.

UNIVERSE = SYSTEM + SURROUNDING

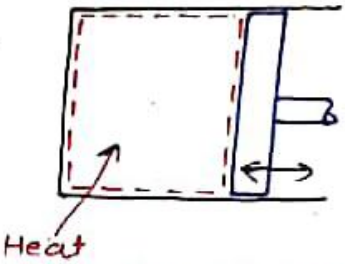


Boundary:- The separation between system and surroundings is known as boundary.

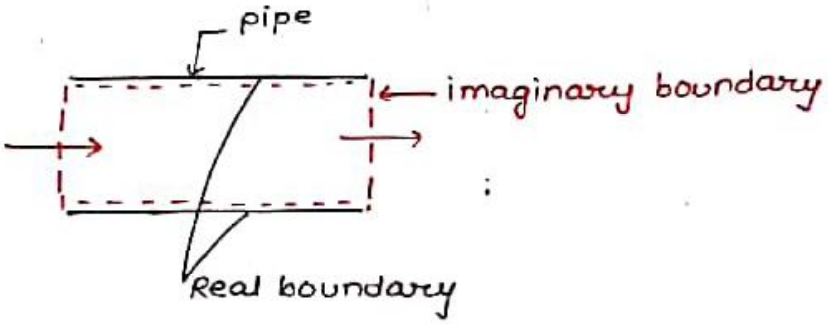
Note: Boundary can be rigid (Fixed), it can be Flexible (Movable), it can be real or imaginary.



Rigid container, Rigid boundary



Movable boundary



Type's of System:→

Type of System	Mass transfer	Energy transfer	Example
closed	X	✓	Water in sealed container, piston cylinder without valve
open	✓	✓	Turbine, compressor, pump, boiler
Isolated	X	X	universe, Hot tea in well insulated Flask.

Note:

In a closed system, as there is no mass transfer, the system mass remains constant and hence it is also known as control mass system.

Control Volume:

It is the volume enclosing or surrounding the device which we wish to analyse. Across the control volume both mass transfer and ~~Heat tra~~ Energy transfer can take place.

Microscopic and Macroscopic Approach of thermodynamics:

In Microscopic approach the behaviour of individual Molecules is taken into consideration, this approach is also stastical thremodynamics. This approach is usefwl at low densities (at higher altitudes).

In Macroscopic approach individual Molecular behawiour is not taken into consideration that is Average behawiour of molecules is taken into consideration. This approach is also known as classical thermodynamics.

NOTE:

In our Course we follow classical thermodynamics.

Thermodynamic Equilibrium:-

A System is said to be in thermodynamic equalibrium if it is in -

(1) Thermal equilibrium (equality of temperature)

(2) Mechanical equilibrium (equality of pressure/forces)

(3) chemical equilibrium (equality of chemical potential)

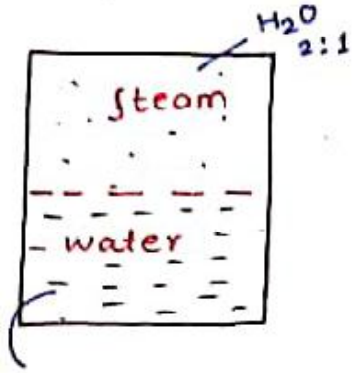
Pure Substance:

A substance is said to be pure substance if it is

(1) Homogeneous in chemical composition.

(2) Homogeneous in chemical aggregation. (bonding)

(1)



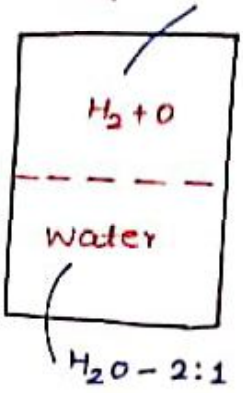
H_2O 2:1

(1) ✓

(2) ✓

(PS) ✓

(2) 2:1



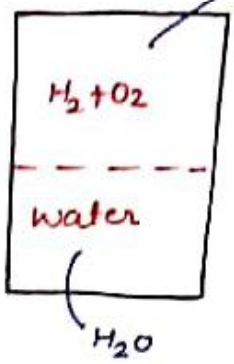
$H_2O - 2:1$

(1) ✓

(2) ✗ No bonding b/w H_2 & O

(PS) ✗

(3) ~~2+2~~ 1:1



H_2O

2:1

(1) ✗

(2) ✗

(PS) ✗

- A pure substance can exist in a single phase or more than one phase.
- Dry air is a pure substance but moist air (liquid air) is not a pure substance that is, in moist air water vapour can be condensed and seperated.
- A pure substance can be mixture of gases also.

Ex: Gaseous air, which is a mixture of Oxygen, Nitrogen and other Inert gases.

Property of a System:

Any Measurable characterstic is a property

Ex: Pressure, Temperature, volume, density etc.

properties are of two types-

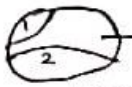
(1) Intensive

(2) Extensive

→ Intensive properties are independent of size or mass.

Examples: pressure, temperature, density, viscosity, Thermal conductivity, Velocity.

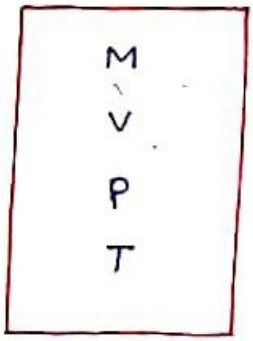
→ 5 m/s travel 5km

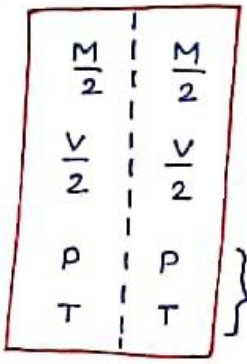


→ 5m/s

→ Extensive properties are dependent on size or Mass of the System.

Ex: volume, Mass, All Forms of Energy, Momentum
(K.E., P.E., internal energy)





NOTE-

(1) Ratio of two extensive properties is an intensive property.
Ex: Density

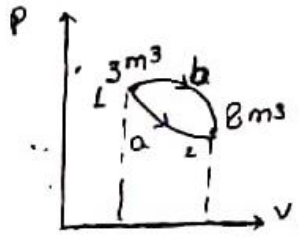
(2) All Specific properties (Extensive properties divided by mass) are intensive properties.
Ex: Specific volume, Specific enthalpy, Specific internal energy, Specific entropy.

Important points w.r.t. properties:

(1) properties are point functions or state functions.

(2) properties are independent of past history i.e. they are independent of path.

[3] Properties are exact differentials.



$dV_a = dV_b = 5\ m^3$

[4] properties are Macroscopic characterstic of a System.

State of a System:

The condition of a system is known as state of a System.

process:-

Any change of state, is a process.

Reversible and Irreversible process:

A process is said to be a reversible process if when revers follows the same path without leaving any effect on system and surrounding.

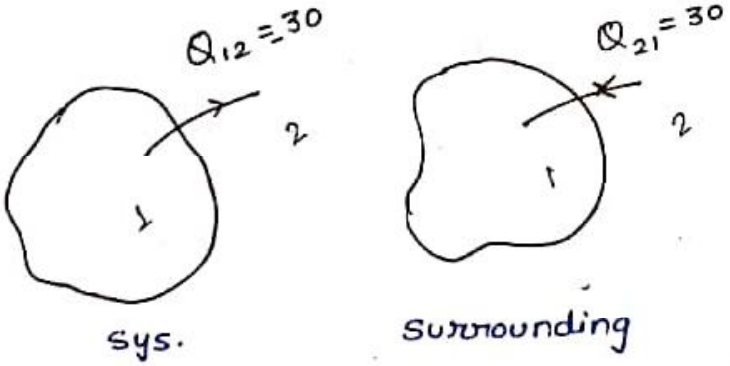
A process which is not a reversible process is an irreversible process. Friction is one of the reason which makes the process irreversible.

- Most of the practical processes are irreversible processes.

Reversible process are discussed-

(i) To simplify the analysis.

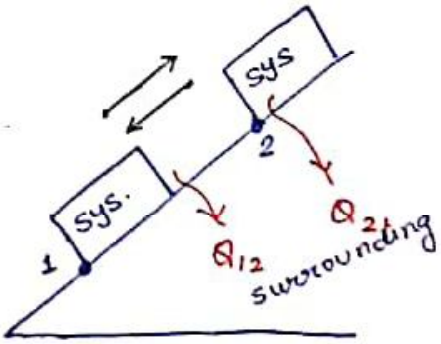
(ii) They are efficient process.



Sys. Surrounding

Q_{12} =	−30	+30
Q_{21} =	+30	−30
	0	0

Reversible



IR-Reversible

→ effect on Surrounding