Department	ELECTRICAL		Programme	3rd Btech ELE	
Subject name	Mechanical engineering ELE		Subject code	MECH ELE	
Semester	3rd	Credits	4	Teacher incharge / mentor	C6
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Lecture 01

Topic: Engineering Thermodynamics

Links: https://www.youtube.com/watch?v=9GMBpZZtjXM

Book: Engineering Thermodynamics by P K Nag Fifth Edition, Page no. 9-13.

Lecture note:

Introduction to engineering thermodynamics

Thermodynamics is the science of energy transfer ad its causes and effects.

- In microscopic thermodynamics, the behaviour of the gas is described by summing up the behaviour of each molecule.
- In macroscopic thermodynamics, the behaviour of the gas is described by the net effect of action of all the molecules, which can be perceived by human senses.

System: A system is a matte or region on which analysis is done. System is separated from the surrounding by boundary. Everything external to the system is called **surroundings**. System and surrounding together is called a **universe.**

	Mass Transfer	Energy Transfer	Example
Open System	Yes	Yes	Compressor, Turbine etc.
Closed System	No	Yes	Piston cylinder arrangement, gas in a closed container
Isolated System	No	No	Universe

Control Volume: Volume surrounding an open system on which study is focussed.

Properties:

Properties are point function and are exact or perfect differentials. For example; internal energy, enthalpy, entropy.

Two types of properties: intensive properties and extensive properties

Intensive properties: Properties are independent of mass. For example; pressure, temperature, density, specific volume, Specific heat (C_p and C_v) etc.

Extensive properties: properties are related to the mass. For example; volume, energy, Heat capacity

Specific Extensive Properties

- Extensive properties per unit mass is specific extensive properties

- It is an intensive properties. For example; Specific volume, Specific energy
- It is independent of mass

Reversible Process

- The process which can be reversed without leaving any effect on system and surrounding
- All reversible processes can be shown on diagrams. For example; P-V, T-S, P-T diagrams.

Irreversible process

- All spontaneous process are irreversible process.
- Irreversible process cannot be shown on diagrams. They are shown as dotted lines. For example; heat transfer through finite temperature difference, free expansion.
- A system will be in a state of thermodynamic equilibrium if the conditions for the following three types of equilibrium are satisfied.
  (i) mechanical equilibrium
  (ii) Chemical equilibrium
  (iii) Thermal equilibrium

Pure Substance: A substance homogenous in chemical composition and homognous in chemical aggregation.

Gibb's Phase Rule

P+F=C+2

P= No. of phases

F= Degree of freedom

C= No. of component

Thermodynamic Cycle

- It is a series of processes when initial and final points are same.
- There is no change in property of system

<u>Lecture 02</u>

<u>Temperature</u>

Topic : Zeroth law of thermodynamics

Link: https://www.youtube.com/watch?v=xQwi9fveGTQ

Book: Engineering Thermodynamics by P.K. Nag fifth Edition, Page no.33-40

Lecture note:

Zeroth law of thermodynamics:

When a body A is in thermal equilibrium with a body B & also separately with a body C then body B and C will be in thermal equilibrium with each other.

Zeroth law of thermodynamics is the basis of temperature measurement.

Measurement of Temperature – The Reference Points

Thermometer	Thermometric property
Constant volume gas thermometer	Pressure (P)
Constant pressure gas thermometer	Volume (V)
Electrical Resistance thermometer	Resistance (R)
Thermo couple	EMF (E)
Mercury in glass thermometer	Length (L)

Thermometers and their temperature range

Thermometers	Temperature range
Platinum resistance thermometers	-200°C to 1200°C
Thermoelectric thermometers	-200°C to 1600°C
Radiation pyrometers	Above 400°C
Segar cone	600°C to 2000°C
Optical Pyrometers	Above 650°C
Gas Thermometers	-200°C to 1200°C

Thermocouple uses copper-constantan, platinum-rhodium, chromel-alumel combinations.

Gas Thermometers

A small amount of gas is enclosed in bulb B which is in communication via the capillary tube C with 1 limb of the mercury manometer M. the other limb of the mercury manometer is open to adjust the mercury levels so that the mercury just touches lip L of the capillary. The pressure in the bulb is used as a thermometric property and is given by

$$p = p_0 + \rho_M Zg$$

Where p_0 is the atmospheric pressure, ρ_M is the density of mercury.

When the bulb is brought in contact with the system whose temperature is to be measured, the bulb, in course of time, comes in thermal equilibrium with the system. The difference in mercury level Z is recorded and the pressure p of the gas in the bulb is estimated. Since the volume of the trapped gas is

Constant, from the ideal gas equation, $\Delta T = \frac{V}{R}\Delta p$ (i)

i.e., the temperature increase is proportional to the pressure increase.

In a constant pressure gas thermometer, the mercury level have to be adjusted to keep Z constant and the volume of gas V, which would vary with the temperature of

Therefore $\Delta T = \frac{P}{R}\Delta V$ (ii)

Ideal Gas Temperature

1. Surround the bulb with steam condensing at 1 atm, determine the gas pressure *p* and calculate

$$\theta = 273.16\frac{p}{1000}$$

2. Remove some gas from the bulb so that when it is surrounded by water at its triple point, the pressure p_t is 500 mmHg. Determine the new value of p and then θ fro steam condensing at 1 atm.

$$\theta = 273.16\frac{p}{500}$$

3. Continue reducing the amount of gas in the bulb so that p_t and *p* have smaller and smaller values, e.g., p_t having say, 250 mmHg, 100 mmHg, and so on. At each value of p_t calculate the corresponding θ.
4. Plot θ vs. p_t and extrapolate the curve to the axis where p_t=0. Read from the graph

$$\lim_{p_t \to o} \theta$$

The graph indicates that although the readings of a constant volume gas thermometer depend upon the nature of the gas, all gases indicate the same temperature as p_t is lowered and made to approach zero.

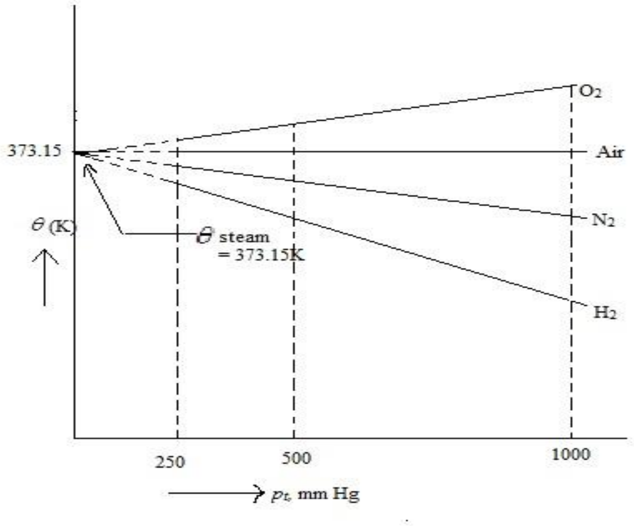

Fig. 1. Ideal gas temperature for steam point

At constant pressure when the bulb is surrounded by steam condensing at 1atm and triple point of water respectively. $\theta = 273.16\frac{V}{V_t}$

And θ vs. *p* may be plotted, similar to fig. 1. It is found from the experiments that all gases indicate the same value of θ as *p* approaches zero.

The ideal gas temperature T is defined by either of the two equations:

$$T = 273.16 \lim_{p_t \to 0} \frac{p}{p_t}$$

$$T = 273.16 \lim_{v_t \to 0} \frac{V}{V_t} \qquad \text{(iii)}$$

Where θ has been replaced by T to denote this particular temperature scale, the ideal gas temperature scale.

If p_s and p_t are the measured pressures at the steam point and the triple point respectively, one gets the value of the steam point temperature T_s as

$$T_s = 273.16 \lim_{v_t \to 0} \frac{V}{V_t} \qquad \text{(iv)}$$

Which is equal to 373.15 K.

Similarly, the temperature of T_i at the ice point is

$$T_i = 273.16 \lim_{p_t \to 0} \frac{p}{p_t} \qquad \text{(v)}$$

However when extrapolated to zero pressure all curves converge, and the ratio p_s/p_i tends to a constant value giving

$$\frac{T_s}{T_i} = \lim_{p_t \to 0} \frac{p_i}{p_t} = 1.366099 \qquad \text{(vi)}$$

This value may be considered as a universal constant.

One may now decide to hbe a certain number of divisions between the steam point and ice point, say 100 as in the Kelvin and Celsius scales so that

$$T_s - T_i = 100 \qquad \text{(vii)}$$

T_s =373.15 K and T_i = 273.15 K

Celsius Temperature Scale

The Celsius temperature scale employs a degree of the same magnitude as that of the ideal gas scale, but its zero point is shifted, so that the Celsius temperature of the triple point of water is 0.01 degree Celsius or 0.01^{o}C. if t denotes the Celsius temperature, then

$t = T - 273.15^{o}$

thus the Celsius temperature t_s at which steam condenses at 1atm. Pressure

$t_s = T_s - 273.15^{o} = 373.15 - 273.15 = 100.00^{o}C$

Similar measurements for ice points show this temperature on the Celsius scale to be 0.00^{o}C. the only Celsius temperature which only fixed by definition is that of the triple point.