Measurent of Humidity and Moisture:-

- Water vapour is one of the constituent gases of Earth's atmosphere, the total pressure P of which is, according to Dalton's law, sum of partial pressures. This means that,

$$P = P_{N_2} + P_{O_2} + P_{H_2O} + P_{other\ gases}.$$

- In average environmental conditions, water is present in liquid and solid phase.
- An empty space in equilibrium with a flat water (or ice) surface can, at a given temperature, hold a well-defined maximum quantity of water vapour.
- When this saturation vapour pressure is reached, any further addition of water vapour results in 'condensation'

There are several ways to express humidity:

1. The vapor pressure is that part of total pressure contributed by water vapor.
2. The absolute humidity (or vapor concentration or vapor density) is the mass of water vapor per unit of volume.
3. The dewpoint temperature is the temperature to which a gas must be cooled, at constant pressure to achieve saturation. When the condensate is ice, it is called 'frost-point'
4. The relative humidity is the ratio of actual vapor pressure and saturation vapor pressure at prevailing temperature.

Humidity and Moisture Measurement

- Whether one likes it or not, water and water vapour can be found everywhere.
- Water Vapour in the air or any other gas is generally called 'humidity', in liquid and solids, it is usually designated as 'moisture'.

Importances and Applications:-

- In prediction of floods, fog, conditions for the appearances of plant diseases etc, determination of humidity and moisture is economically important.
- Stored foodstuffs or raw materials may dry up at low humidity or get moldy/stale at high humidity.
- In many industrial processes, their determination is important for maintenance of optimum condns in manufacturing.

→ Humidity and moisture content can be expressed in a no of ways, and no of methods for measuring them is ever greater.

- An engineer whose main concern is to avoid condensation no matter where in his system it will be present. ic interest is 'dewpoint' of gas flow.
- A chemist may be interested in the mere quantity of water vapour, whereas in a printing-office or a storage-room, the 'relative humdity' is of more importance.

Measurement of Moisture and humidity.

Importances and application :-

- Measurement and control of moisture content in gases, liquids and solids is important as it may affect their properties, quality, composition, rate of decay or decomposition, etc.
- In textile and paper industries, on-line measurement of moisture content is essential.
  Also, color printing, drying of wood, leather and successful storage of meat, fruits and eggs requires careful humidity control.

Classification of techniques used for determination of moisture :-

1. Measurement of moisture in gases.
   - Dew-point instruments.
   - Electrical sensor instruments
   - Automatic psychrometers.
2. Measurement of moisture in liquids
   - Infrared instrument
   - Microwave instrument.
   - Vapor pressure sensors.
3. Measurement of moisture in solids.
   - Electrical impedance.
   - Resistive moisture transducers.

- Instrument used for continuous measurement of relative humidity is 'Hygrometers'

Measurement of moisture and humidity in gases.

- The moisture and humidity are usually expressed in terms of 'relative humidity' or 'absolute humidity'.
- Absolute humidity of a gas is defined as mass of water vapour present in a unit volume of gas.
- 'Relative humidity' (RH) of a gas is defined as

$$RH = \frac{(\text{mass of water vapour present in a given volume of gas})}{(\text{mass of water vapour necessary to saturate the same volume of gas at same temperature})}$$

$$= \frac{(\text{saturation vapour pressure at Dew point})}{(\text{saturation vapour pressure at given temp})}$$

- Classical method of determining relative humidity of air is by wet and dry bulb thermometer system known as 'Psychrometer'.

Dew-point Measurement

- Continuous measurement of humidity is now-a-days mostly carried out by measurement of 'dew-point'.

What is Dew-point & how it is formed ?

- When humid air is cooled slowly and continuously a temperature reaches at which water vapour present in air is sufficient to saturate the air.
- Any further cooling causes vapour to be deposited on surface of objects in its vicinity, in form of 'dew'.

Dew-point Measurement (continue).....

- The temperature at which this dew formation occurs is defined as 'dew-point' for a sample of air.

Dew-Point Instruments:-

- Principle of dew-point instruments is based on the fact that a surface exposed to the atmosphere is cooled when dew appears.
- The temperature of surface when condensation first appears is the 'dew-point temperature'.

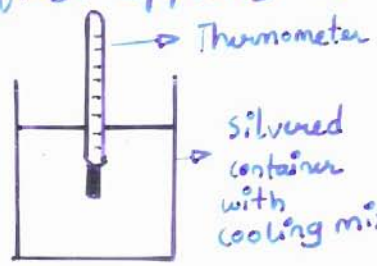

fig (a): Simple dew-point apparatus

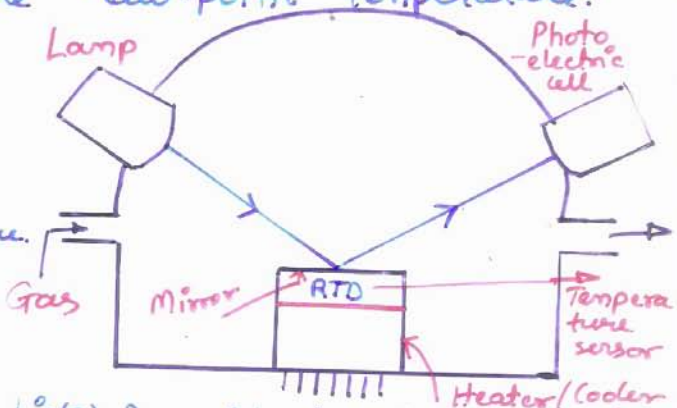

fig (2): Dew-point mirror instrument system

- In a simple dew-point apparatus, a polished surface is slowly cooled or heated until dew appears or disappears, respectively.
- The temperature is measured by a thermometer.
- This simple instrument is used in range of $-60^{\circ}C$ to $100^{\circ}C$.
- In a dew point mirror instrument as shown in diagram (2), the temperature at which moisture condenses on a plane mirror can be readily estimated.

- The temperature is measured by a platinum (RTD) resistance thermometer placed just behind the mirror surface.
- The onset of dew is detected by the change in reflectivity measured by a lamp and a photocell.
- The dew-point temperature can be measured auto-matically by providing a feedback circuit between the photoelectric cell and the heater/cooler system.

Electrical Sensor Instruments:-

- Electrical methods are widely used to measure moisture content in textile, lumber, leather and tobacco industries.

Two types

1) Conductivity sensor instrument

Basic principle here is that conductivity of certain material varies with moisture content

- Detector element with electrodes forms a part of wheat-stone's Bridge with suitable indicator.

2) Capacitive Moisture transducer

operates on principle that dielectric constant changes with a small changes in moisture content.

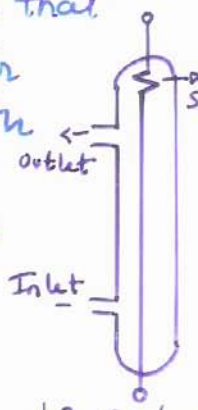

fig Conductivity sensor instrument.

Capacitive Moisture Transducer

- Dielectric constant of pure water is 80 and that of most insulating materials, solids or liquids is less than 10 and so it is possible to measure the 'moisture content' of these materials by measuring the dielectric constant of moist solid or solution of the substance in water.

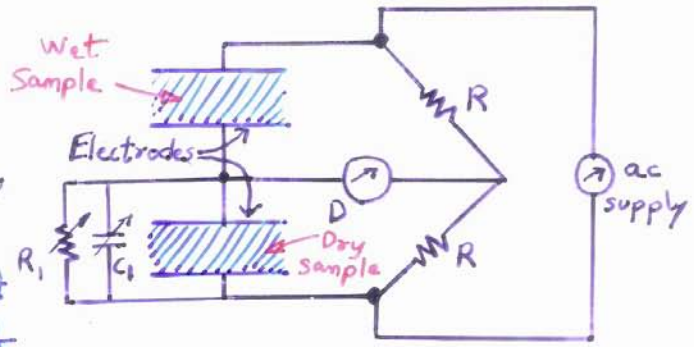

fig. A Capacitive moisture transducer

- It operates on principle that dielectric constant changes with a small change in moisture content.
- The equivalent series or shunt resistance of capacitor, representing the dielectric losses of the sample, may also be used to indicate the moisture content.
- Two identical capacitors, one holding the test sample and the other the dry sample, may be used in an ac bridge circuit, and the equivalent loss resistance as well as the capacitance may be measured by balancing the bridge.
- As the capacitances values ↑scs with moisture and equivalent shunt resistance falls, the arm with dry sample may be shunted by a variable capacitor and resistor as shown in figure above. and their values may be calibrated against the moisture contents.
- The technique is suitable and reliable for solid materials that absorb moisture all through substances.
- Method is unsuitable for certain materials that allow moisture to settle on the surface only but do not absorb, thus the measurement of moisture will not be correct.
- The choice of frequency of supply voltage for the bridge circuit is critical as electrical conductivity and dielectric constant of water change considerably at frequencies above 10KHz.

Measurement of moisture Contents of Solids:-

- Electrical resistivity of materials such as wood, grain, flour in powder form ↓ses when the moisture content of material ↑ses.
- The majority of techniques used for measuring the moisture content of such materials involve measurement of electrical resistance.
- The material is held in close contact with a pair of electrodes of suitable size.

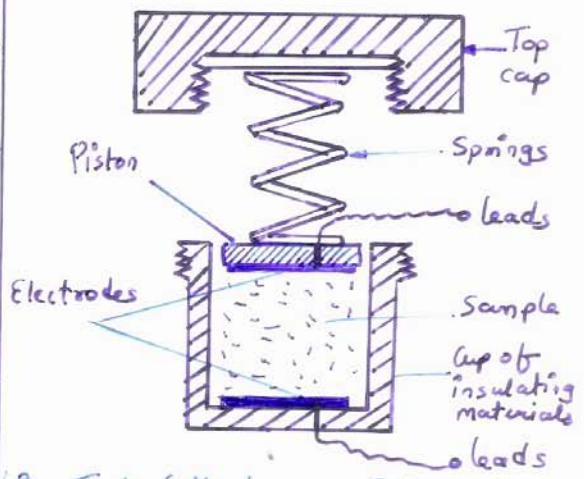

fig: Test Cell for moisture measurement of granular substances.

- All samples of powder materials or grains or textiles should be brought to a high degree of compression between the electrodes.
- Above figure shows the details of the electrode system and the provision made for compaction of powder material.
- After filling the cup with a measured quantity of the sample, the top cap holding the spring-loaded piston is screwed down fully so as to develop the required pressure on the material.
- Actual moisture content of the sample is determined by weighing it after it is fully dried.
- For each material and its electrode system, the characteristic between resistance and moisture content is established by calibration.