UNIT-VI

MEASUREMENT OF PHYSICAL PARAMETERS.

In many industrial applications, it is required to measure large no. of mechanical quantities like temperature, pressure, flow, velocity, acceleration and so on. These quantities are measured with high degree of accuracy by using primary measuring system which is made up of primary sensing element or sensor and additional supporting elements.

To measure above mentioned mechanical quantities, mechanical transducers are used. These are primary sensing elements which are in direct contact with system and follows the changes in system during measurement.

FLOW MEASUREMENT:

The materials introduced to the manufacturing process and amount of materials evolved by the process needs to be monitored. Flow measurement is made for purpose of cost accounting for steam, chemical, oil and gases.

Fluids in a closed pipe can be measured by no. of methods:

1) Head meters, where pressure differential across a suitable restriction to flow is measured.
2) Area meters measure variation in flow area of stream.
3) Velocity meter is used to measure flow rate.

DISPLACEMENT MEASUREMENT: It can be classified as:

1. Translational displacement.
2. Rotational displacement.

The motion of a body is a straight line between two points is called translational displacement.

The motion of a body of angular type, about some rotation axis is called rotational displacement.

Displacement transducers are not only measure translational motion but also can be used as secondary transducer in measurement system. Similarly, the rotational transducer measures not only rotational displacement but also the translational displacement of a body.

MEASUREMENT OF HUMIDITY AND MOISTURE:

The amount of water vapour content in the atmosphere, i.e., humidity is an important process, this is because humidity content effects the behaviour of many commercial materials such as paper, textiles, paint, tobacco, soap powder, fertilizers, leather wood products etc.

Relative humidity (R_H) compares the humidity of air with humidity of saturated air at same temperature and pressure.

R_H is defined as the ratio of mass of water vapour present in a given volume of gas to the mass of water vapour necessary to saturate the same volume of gas at the same temperature.

VELOCITY MEASUREMENT:

Here we consider devices for measuring the velocity of translation, along a line, of one point relative to another and the plane rotational velocity about a single axis of one line relative to another.

FORCE MEASUREMENT:

The transducers (or) devices used for force measurement are also called load cells. Both static and dynamic force measurement will be considered. The magnitude of static (or) dynamic forces being considered may vary from a fraction of a Newton to several mega Newtons. For dynamic measurements, electro-mechanical transducers are often used.

PRESSURE MEASUREMENT:

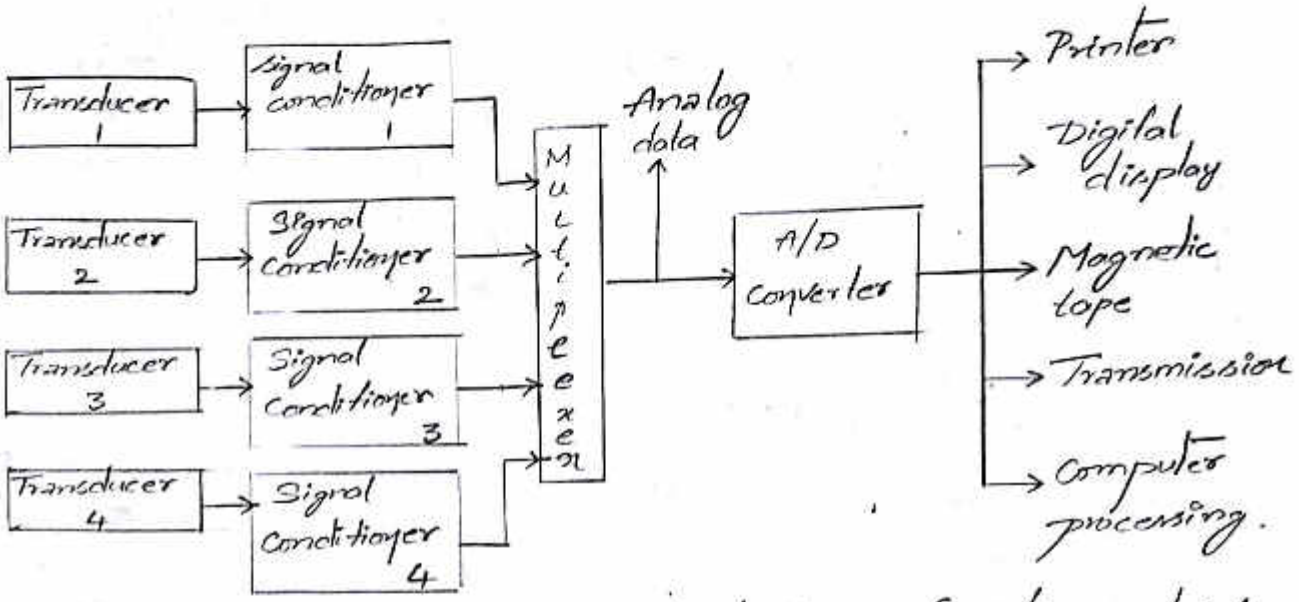
In the process industry, measurement and control of a fluid pressure is a common requirement. Because of important of fluid pressure in level measurement as well as flow measurement, the pressure measurement is very important process in the industry.

MEASUREMENT OF TEMPERATURE:

It is one of the important events in the process industries. Temperature is the measure of hotness (or) coldness of that substance. when two bodies are placed close to each the heat always flows from a body at high temp. to the body at low temp.

DATA ACQUISITION SYSTEM:

A typical data acquisition system consists of individual sensors with the necessary signal conditioning, data conversion, data processing, multiplexing, data handling and associated transmission, storage and display systems.



The important factors that decide the configuration and sub s/m of data acquisition s/m as follows:

1. Acquisition and resolution
2. No: of channels to be monitored.
3. Analog (or) digital signal.
4. Single channel (or) multiple channel.
5. Sampling rate per channel.
6. Signal conditioning requirements of each channel.
7. Cost.

Types of flow meter :-

① Head type flow meters
② Variable area meter (Rotameter)
③ Mechanical flow meter
④ Electromagnetic flow meter
⑤ Anemometer
⑥ Ultrasonic flow meter
⑦ vertex flow meter

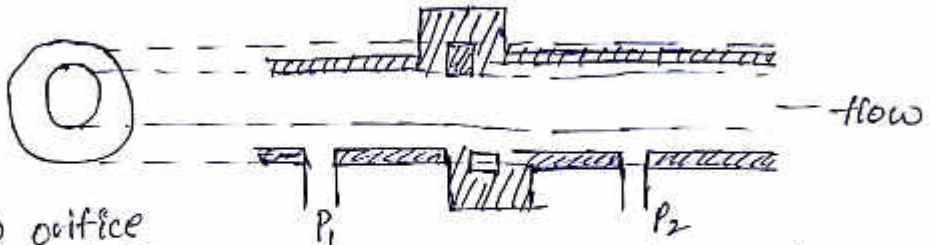
Head Type flow meter :-

In there type of flow meters, some device is inserted into a pipe carrying fluid. It obstructs the flow of fluid and cueter a pressure difference on either side of the device. The most commonly used devices are.

(i) Orifice plate
(ii) venturi tube
(iii) flow nozzle
(iv) doll flow tube
(v) pitot tube

Orifice plate

The Orifice plate is a metal disk with a concentric hole as shown in figure. It is the simples device used almost all industrial applications because of cheapmen and availibility in wide range of sizes.



a) orifice plate

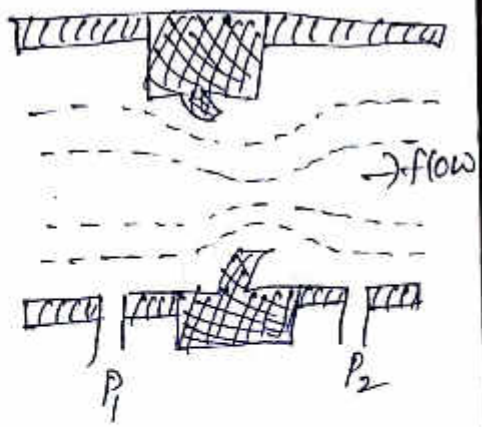
b) flow acron orifice plate

There are certain limitation of the orifice plate. for very high flow rates, the temanent pressure losses are very high. Over a period of time, the sharp edges of the hole wear out and the particles in the flowing fluid build up behind the hole reducing the diameter.

② Flow nozzle :-

A compared to the orifice plate, flow nozzle is a better option an possibility of solid particles bubbles of gas sticking in the flow restriction.

the measurement accuracy of the flow nozzle is very high as no hearm of getting warned out. Fabrication of flow nozzle is difficult. Also permant pressure losses are also high similar to the orifice plate. The flow nozzles are typically used for steam.



measurement.

Direct Method :-

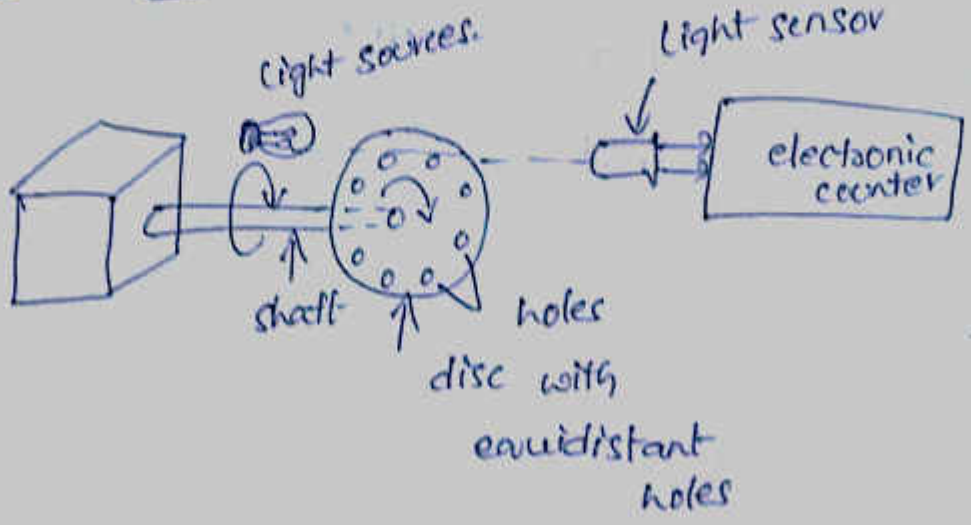
Some method, by which the actual liquid level is directly indicated are by mean by a simple mechanical type of device. Here use discum a float operated scheme with electrical o/p. In this, the float acts an primary transducer that converts liquid level variation into a suitable displacement. this displacement is by the secondary transducer such as resistance type of potentiometri device, inductive type of LVDT etc.

Figure shows the schematic of the actuated rheostatic device. The float displacement actuates the arm that causes the slider to move over the resistive element of a rheostat.

Digital Method of measurement of velocity :-

The earlier methods can be used for measuring speeds of 10,000 rpm or len. For higher speeds, digital methods can be used.

photo electric tachometer



In this method, an opaque disc is mounted on a rotating shaft. Along the periphery of the disc, there are equidistant holes. At one side of the disc, a light source is used. Along the same axis, on other light source.

When shaft rotates at an unknown speed the disc with equidistant holes also rotates at the same speed. When a hole comes of the light source, light through it and falls on the light sensor which produces a pulse. But when opaque portion of source in light can through then no pulse is generated.

Advantages :-

① The o/p of a techometer is pubed output, which is in digital form, hence can be easily inter faced to digital instruments without connecting an ADC.

② The amplitude of pulses produced every time is to constant, hence complex electronic circuitry is not repuired.

Disadvantages :-

① life time of the light source is 50,000 to 60,000 hours, hence it has to be replaced time to time.

② the accuracy of the method depends on error represented by one pulse. If the period during too which frequency is measured i.e gating period is too short, errors occur.

Classification of pressure.

① Absolute pressure
② Gauge pressure
③ Vaccum pressure.

Absolute pressure :-

It is defined as the difference between the pressure of the fluid and the absolute zero of the pressure.

Gauge pressure :-

It is defined as the difference between the pressure of a fluid and the standard atmosphere pressure.

Vacuum pressure :-

It is defined as the negative of gauge pressure.

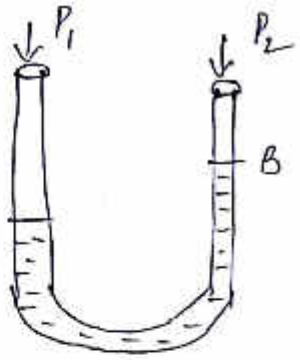
Manometer for pressure measurement :-

It is the most simplest device used for pressure measurement. It is specially used for low pressure measurement. It gives continuous o/p rather than a stepwise o/p.

The commonly used fluids in the manometer are mercury, transformer oil, carbon tetrachloride etc.

U tube Manometer :-

It consists of glass tube of U shape. The pressure measured is the differential pressure and is given by



$$P_1 - P_2 = \rho g h$$

where

ρ = density of liquid

g = gravitational constant

h = difference in heights of liquid levels in two columns

Well type manometer:-

This type of manometer is advantageous than U type manometer because only one reading of single liquid level in single vertical leg is needed rather than two readings of heights in both legs on columns.

High pressure measurement:-

The pressure upto 10000 psi can be measured satisfactorialy with the help of stain gauge or Boundom tube. when the pressure is above 10000 psi then use have to use high pressure measurement techniques. Electrical gauges based on resistance change can be used.

Vaccum Measurement :-

The pressure below atmospheric pressure is refered to as vaccum pressure. Vaccum ranges are.

Medium high — 1 to 10^{-3} torrs

High vaccum - 10^{-3} to 10^{-7} torrs

Very High vaccum - less than 10^{-7} torrs.

Vaccum measurement can be done using.

(i) Melod guage
(ii) Thermal conductive gauge
(iii) Ionization gauge.

Melead gauge for pressure measurement :-

The melead gauge in used for measurement of low pressure. It is a special development of a sealed U tube manometer is which low pressure.

Principle of Operation :-

It is based on Boyle's law, which states that 'At constant temp for a fixed man of product of pressure and volume of a V_1, with a pressure P_1 is trapped and then compressed new volume V_2 at a new pressure P_2.

Hence according to Boyle's law

$$P_1 V_1 = P_2 V_2$$

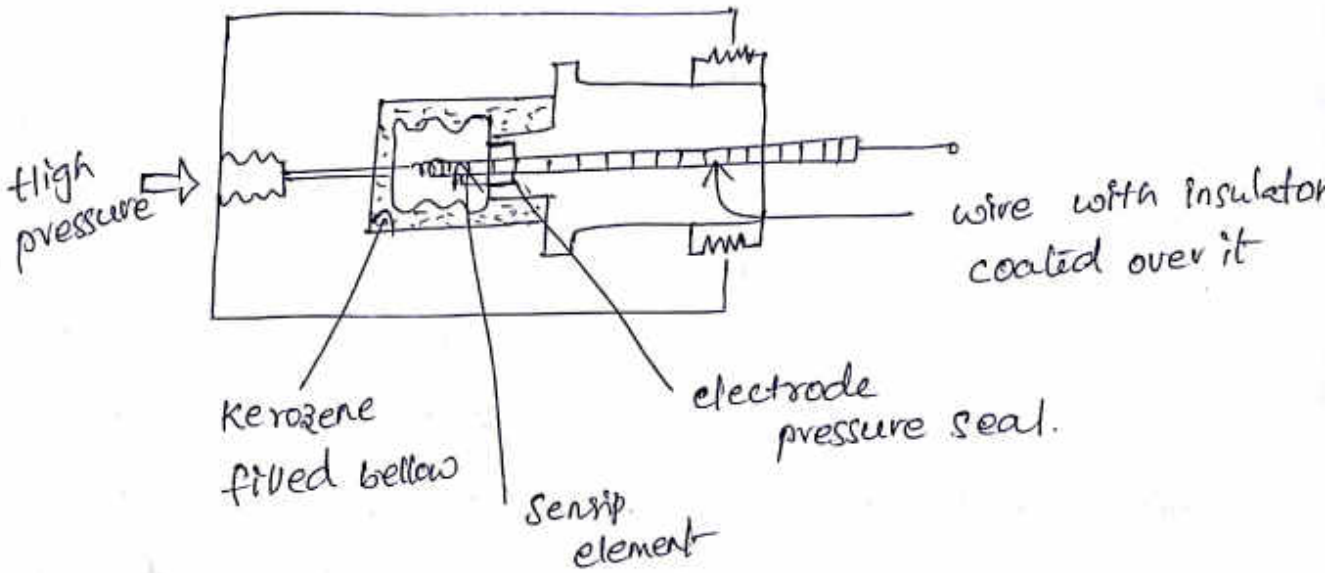
Here V_1, V_2 and P_2 are known and from the known values, an initial unknown pressure P_1 can be calculated

$$P_1 = \frac{P_2 V_2}{V_1}$$

Construction and working:-

The general form of Meleod gauge is shown in the figure. Generally mercury is used for trapping a known sample of volume of a gas.

The coil is enclosed in a flexible filled bellows. The kerozene filled bellow transmits measured pressure to the coil.

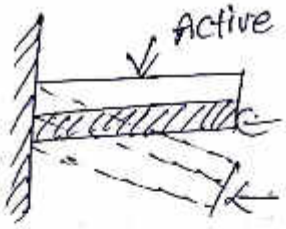


The gold-cheome wire is preferred over manganis wire because its temp sensitivity is lower as compared with that of manganism wire. Over a range of 40°F to 100°F, there is only 0.01% of temp sensitivity for gold-chrome wire.

Bimetallic thermometer :-

It is based on the principle that if two strips of different meter are joined together then with the change in temp applied, causes a bend in the strip.

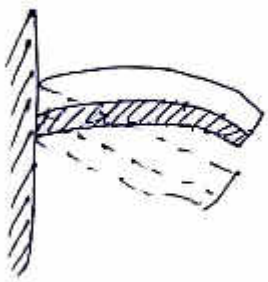
The simplest type of bimetallic strip is flat straight bimetallic strip.



Two metals with different coefficients of expansion are bonded together forming a bimetallic strip unit.

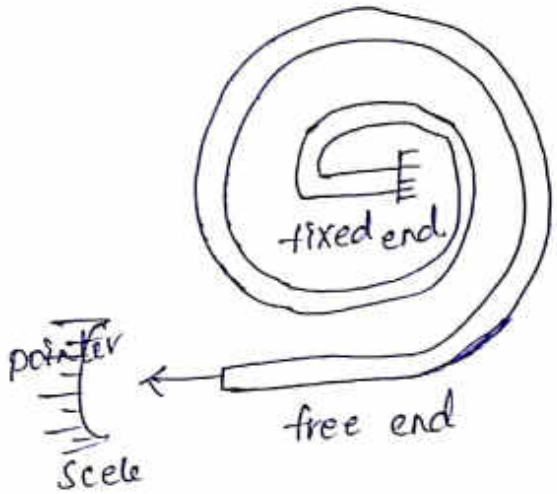
The strip remain flat and straight at the temp at which the metal pieces are bonded. when the strip is healed to high temp, the strip bends towards metal side having lower coefficient of thermal expnsn.

The same technique is used in the curved bimetallic strip as shown below.



curved bimetallic strip.

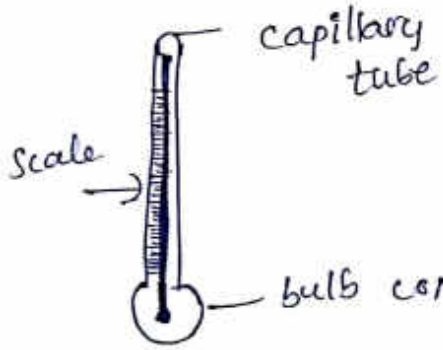
To obtain higher sensitivity, spiral bimeticallic strip is used as shown below Here the thickness of the strip is kept lower than the radius of curvature.



For visual indication, at the free end of strip, a pointer with scale is mounted which gives direct indication of temp on calibrated scale. To get electrical output, LVDT can be used.

Liquid-in-gas thermometer:-

It is the most common temp measuring instrument used widely in various applications. The liquid used is either mercury or colored alcohol. This fluid is contained within a bulb and a capillary tube.



When the temp of the surrounding increases, the fluid in the bulb expands along the capillary tube.

This type of thermometer is used in industrial applications to measure temp within -200°C to 1000°C range.

Data Acquisition system:-

To optimise the characteristics of the system in terms of performance of the system + data handling capacity and cost, different relevant sub systems are combined together.

DAS are basically used to measure and record the signals obtained. The signal may be originating from direct measurement of an electrical quantity sub as ac or dc voltage, frequency etc.

DAS is mainly classified as analog DAS and digital DAS.

Analog Data Acquisition system:-

The basic components used in analog DAS are as foll.

① Transducer:-

It is used to convert the physical quantity into an electrical signal. Transducers such as strain gauge, thermocouple, piezo electric device are

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are widely used The transducer generates a voltage proportional to the physical quantity being measured This voltage is applied as input to DAS.

② signal conditiones :-

This device includes the sipports circuitry for the transducer. It allows the o/p voltage of the transducer to amplify upto desired level.

③ Multiplexer :-

It allows a single channel to share it with more than one input quantity. It accepts multiple analog inputs. Using multiplexer, we can transmits more than one quantity using the same channel.