T.Y. Diploma : Sem. V
[ME/MH/MI/PG/PT]

Measurement & Control

Time: 3 Hrs.] Prelim Question Paper Solution **[Marks : 100**

Q.1 Attempt any ten from the following : [20]

Q.1(a) Define the term, 'Threshold', 'Resolution', 'Repeatability' and 'Reproducibility'. [2]

Ans.: Threshold:

It is defined as the minimum value of input below which no output can be detected. It is instructive to note that the resolution refers to the smallest measurable input above the zero value.

Resolution

It is defined as the smallest increment in the measured value that can be detected with certainty by the instrument. In other words, it is the degree of fineness with which a measurement can be done.

Least count of any instrument is taken as resolution of the instrument.

REPEATABILITY:

It can be defined as the ability of the instrument to reproduce a group of measurements of the same measured quantity, made by the same observer, using the same instrument, under the same conditions.

REPRODUCIBILITY:

Reproducibility is the consistency of pattern of variation in measurement i.e. closeness of the agreement between the results of measurements of the same quantity, when individual measurements are carried out:

- By different observers,
- By differential instruments
- Under differential conditions, locations, time, etc.

  It may also be expressed quantitatively in terms of the dispersion of the results.

Q.1(b) Compare hydraulic and electronic control systems. [2]

Ans.:

Hydraulic controllers	Electronic control system
Uses oil as a working media	Electricity is operating medium
Speed of response is slow	Extremely high speed of response
More space is required	Less space is required
Fairly good accuracy	Very high accuracy
Unaffected by electrical noise	Susceptible to noise pick-ups
Are complicated and difficult to maintain	Are simple and easily maintained

Q.1(c) List the advantages and disadvantages of capacitive transducers. [2]

Ans.: Advantages of capacitive transducers:

1) They require extremely small forces to operate them and hence are very useful for use in small systems.
2) They are extremely sensitive.
3) They have good frequency response.
4) They have high input impedance and therefore the loading effects are minimum.
5) Required small power to operate.

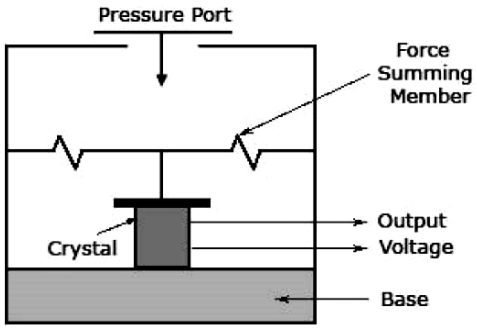
Disadvantages:

1) The metallic parts of the capacitive transducers must be insulated from each other in order to reduce the effects of stray capacitances, the frames must be earthed.
2) The capacitive transducer show non–linear behavior many a time on account of edge effects.
3) The output impedance of capacitive transducer tends to be high on account of their small capacitive value.
4) They are temperature sensitive.
5) The instrumentation circuit used with these transducers in very complex.
6) The capacitance may change on account of presence of dust particles and moisture.

Q.1(d) How pressure is measured by piezoelectric transducer? Explain. [2]

Ans.: The main principle of a piezoelectric transducer is that a force, when applied on the quartz crystal, produces electric charges on the crystal surface. The charge thus produced can be called as piezoelectricity. Piezoelectricity can be defined as the electrical polarization produced by mechanical strain on certain class of crystals. The rate of charge produced will be proportional to the rate of change of force applied as input. As the charge produced is very small, a charge amplifier is needed so as to produce an output voltage big enough to be measured. The device is also known to be mechanically stiff. For example, if a force of 15 kiloN is given to the transducer, it may only deflect to a maximum of 0.002mm. But the output response may be as high as 100 kiloHz. This proves that the device is best applicable for dynamic measurement.

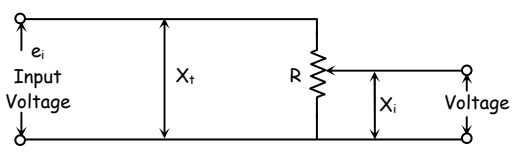
The figure shows a conventional piezoelectric transducer with a piezoelectric crystal inserted between a solid base and the force summing member. If a force is applied on the pressure port, the same force will fall on the force summing member. Thus a potential difference will be generated on the crystal due to its property. The voltage produced will be proportional to the magnitude of the applied force.

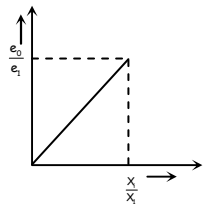


Piezo-Electric Transducer

Q.1(e) Draw a neat sketch of linear Potentiometer for displacement measurement, explain its working. [2]

Ans.: The translatory resistive elements are straight or linear devices used for measurement of liner displacement.





Working Principle

Positioning of the slider by a external force varies the resistance in potentiometer or a bridge circuit.

Consider a traslatory or liner potentiometer as shown in figure.

Let ei and eo = Input and Output voltages,

Xt = Total length of liner pot in meter

Xi= Displacement of wiper from its zero position in meter

Rp= total resistance of potentiometer.

The movement is linear, so resistance per unit length is Rp / Xi

Hence, output voltage is ,

$$e_0 = \left(\frac{\text{Resistance at the output terminal}}{\text{Resistance at the input terminal}} \times (\text{Input voltage})\right)$$

$$e_0 = \left(\frac{R_p \times \frac{X_i}{X_t}}{R_p} \times (e_i)\right)$$

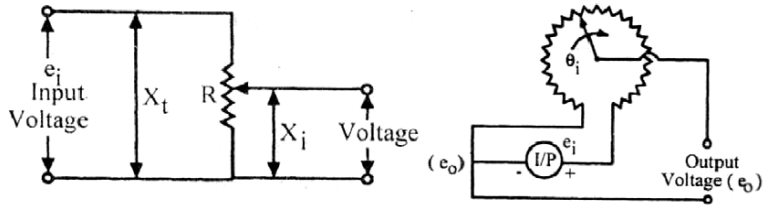
$$e_0 = \left(\frac{\frac{X_i}{X_t}}{R_p} \times (e_i)\right)$$

$$= \frac{X_i}{X_t} \times (e_i)$$

Under ideal circumstances, the output voltage varies linearly with displacement as shown in figure.

Q.1(f) State and explain working principle of potentiometer. **[2]**

Ans.: Potentiometer is passive transducer since it requires external power source for its operation. Basically a resistance potentiometer consists of resistance element providing with a sliding contact. The sliding contact is known as wiper. The motion of the sliding contact may be translatory or rotational. Some have a combination of both motions with resistive element in the form of helix so called heliport.



$$e_0 = \left(\frac{R_p \times \frac{X_i}{X_t}}{R_p} \times (e_i)\right)$$

Q.1(g) Define sensitivity drift and zero drift. What factors can cause sensitivity drift and zero drift in instrument characteristics? **[2]**

Ans.: **Sensitivity drift** : It there is proportional change in the indication all along the upward scale the drift is called sensitivity drift.

Zero Drift : If the whole calibration gradually shifts due to slippage, permanent set, or due to undue warming up of electronic tubes circuits, zero drift sets.

Factor causing Sensitivity drift and zero drift :–

1) Stray electric and magnetic fields.
2) Thermal emfs.
3) Change in temperature.
4) Mechanical vibrations.
5) Wear and tear.

Q.1(h) What is transducer? Classify the transducer. **[2]**

Ans.: A transducer senses the desired input in one physical form and converts it to an output in another physical form. Example: The input variable to the transducer could be a pressure, acceleration. Temperature and the output of transducer may be displacement, voltage or resistance change depending on type of transducer element.

Classification of transducer

Active Transducer: These transducers does not require external source of power to produce their output.

Passive Transducer: These transducer derive the power required for generating output from an external source of power.

Resistive Transducer: This type of transducer converts the input into change in resistance.

Inductive Transducer: These type of transducers convert the input into change in inductance.

Capacitive Transducer: These type of transducers convert the input into change in capacitance.

Q.1(i) What are active and passive transducers? Give two examples of each. **[2]**

Ans.: **Active transducer :** they generate equivalent electrical output signal without any external energy or energizing source.

Examples : thermoelectric transducer, piezo-electric transducer, photo-voltaic transducer etc.

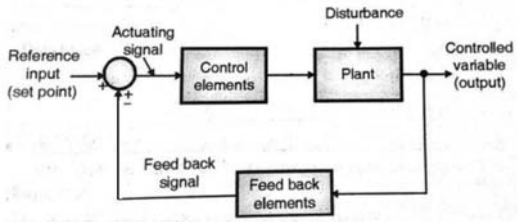
Passive transducer : the measurand is converted into passive parameter such as resistance, inductance or capacitance, which needs an external electrical supply so as to get an equivalent electrical output.

Examples: resistive transducer, inductive transducer, capacitive transducer, piezo-resistive transducer, thermo- resistive transducer.

Q.1(j) Draw the block diagram of a feedback control system and describe it in brief. **[2]**

Ans.: **Feedback control system**

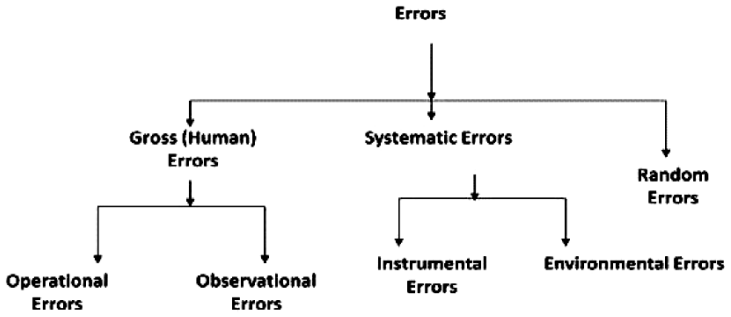
- Figure shows the basic elements of a feedback control system . The block diagram represents flow paths of control signals , but does not represent flow of energy through the system or process.
- The plant is the system or process through which a particular quantity or condition is controlled.
- The control elements are components needed to generate the appropriate control signal applied to the plant. These elements are also called the controller.
- The feedback elements are components needed to identify the functional relationship between the feedback signal and the controller output.
- The reference point is an external signal applied to the summing point of the control system to cause the plant to produce a specific action.
- The controller output is the quantity or condition of the plant which is controlled.
- The feedback signal is a function of the output signal. It is sent to the summing point and algebraically added to the reference input signal to obtain the actuating signal.
- The actuating signal represents the control action of the control loop and is equal to the algebraic sum of the reference input signal and feedback signal. This is also called the error signal.
- The disturbance is an undesirable input signal that upsets the value of the controlled output of the plant.



Feedback control system block diagram

Q.1(k) What are different types of errors in measurement system? Give classification. [2]

Ans.: Errors arise from different sources and are broadly classified as:



Gross Error or Human Error

This class of errors mainly covers human mistakes in reading instrument, in recording and calculating measurement results. The responsibility of the mistakes wholly lies with the operator.

Gross errors are further classified in to two types:

- Observational errors
- Operational errors

Observational Errors

There are many sources of observation errors. As an example, the pointer of a voltmeter rests slightly above the surface of the scale. Thus an error on account of parallax will be occurred unless the line of the observer is exactly above the pointer.

Operational Errors

Quite often errors are caused by poor operational techniques. There is an old saying that instruments are better than the people who use them. Too often the errors caused in measurements are due to the fault of the operator than that of the instrument. A good instrument used in a unintelligent way gives erroneous results.

Systematic error

Instrumental errors:

- These errors arise due to the following reasons:
- Due to inherent shortcoming in the instrument
- Zero error
- Calibration error

Environmental errors:

- These errors are due to conditions external to the measuring device, i.e. in the area surrounding it. These may be effects of temperature, pressure, humidity, dust, vibrations or presence of external magnetic or electro static fields.
- Consider mercury-in glass thermometer being used for the measurement of air temperature. The instrument will located wrongly if during measurements the sun happens to be shining on the thermometer bulb. Also, if the thermometer is place too close to a window then the bulb would indicate an effect of heat radiation due to window.
- In the above case the thermometer will give a high temperature reading.

Random Error:

- Even after removing all the systematic errors measurement results show variation from one reading to another.
- The quantity being measured is affected by many factors throughout the universe.
- Out of these much factors we are aware about very few factors.
- The factors about which we are unaware are known as "Random or Residual", and the error occurs due to these factors are called "Random or Residual errors"

Q.1(l) Define intensity of sound & sound pressure. **[2]**

Ans.:

- **Intensity**

  Sound intensity is defined as the sound power per unit area. The usual context is the measurement of sound intensity in the air at a listener's location. The basic units are watts/m^2 or watts/cm^2.

- **Sound pressure level (SPL)**

  It is the difference between the pressure produced by a sound wave and the barometric (ambient) pressure at the same point in space, symbol p or p. these are often used in the measurement of sound levels.

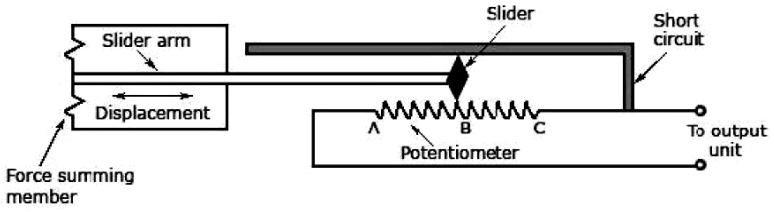
Q.1(m) Explain working of any one displacement transducer. **[2]**

Ans.: Explanation of any one of the following considered.

(Linear potentiometer transducer, capacitive transducer, piezoelectric transducer, LVDT, linear motion variable inductance transducer, proximity inductance transducer etc.)

1. **Linear Potentiometer Transducer:**

   A linear potentiometer transducer consists of a potentiometer, which is short circuited by a slider. The other end of the slider is connected to a slider arm. The force summing device on the slider arm causes linear displacement of the slider causing the short circuit of a certain portion of the resistance in the potentiometer. Let the whole resistance positions on the potentiometer be ABC. Let the resistance position caused by the slider movement be BC. As the movement of the slider moves further to the right, the amount of resistance increases. This increase in resistance value can be noted according to the corresponding change in the linear displacement of the slider. The change in resistance can be calculated with the help of a Wheatstone bridge. Another easy method than calculating the resistance with the help of a bridge connection is to connect a constant current source in series with the potentiometer. Thus a voltage will be developed. This voltage can be measured and hence the resistance, R = V/I.

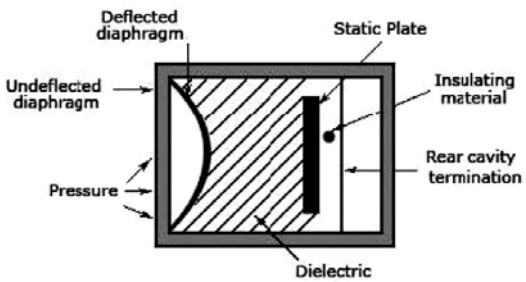


Linear Potentiometer

2. **Capacitive Transducers:**

   As shown in the figure below, a capacitive transducer has a static plate and a deflected flexible diaphragm with a dielectric in between. When a force is exerted to the outer side of the diaphragm the distance between the diaphragm and the static plate changes. This produces a capacitance which is measured using an alternating current bridge or a tank circuit.

Capacitive Transducer



A tank circuit is more preferred because it produces a change in frequency according to the change in capacitance. This value of frequency will be corresponding to the displacement or force given to the input.

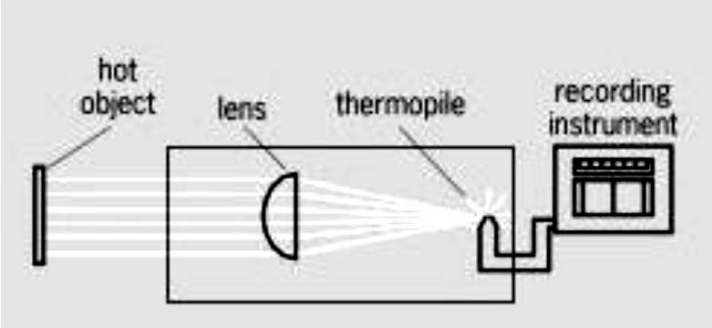
Q.2Attempt any FOUR the following : [16]

Q.2(a) Explain working principle of temperature measuring instrument for temperature upto 2200°C. [4]

Ans.: Explanation of any pyrometer

Radiation or Optical Pyrometer

Pyrometry is a technique for measuring temperature without physical contact. It depends upon the relationship between the temperature of hot body and electromagnetic radiations emitted by the body. When the body is heated it emits thermal energy known as heat radiation. A black surface is very good absorber of heat radiations and very good emitter of such radiations when heated. This method determines the body temperature by measuring its radiations.



Radiation Pyrometer

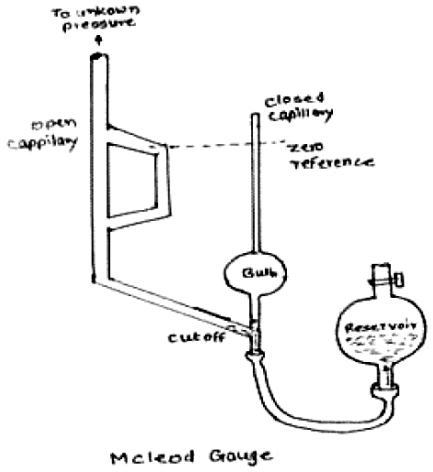
Principle of radiation pyrometer is based on the measurement of radiant energy by the hot body. It consists of a lens to focus radiated energy from the body, whose temperature is to be measured. This receiving element may have Varity of forms such as resistance thermometer, thermocouple or a thermopile. A thermopile consists of several thermocouples connected in seris. A temperature indicator, recorder or controller is attached with receiving element to indicate the temperature.

When the total energy radiated by the hot body whose temperature is to be measured enters the pyrometer it is focused by the lens on to the detector. The detector is a thermopile whose measuring junctions are attached to a blackened disc. The disc absorbs the energy when the pyrometer is focused on a hot body and its temperature rises. The reference junction of thermopile is attached to the pyrometer case. The difference in temperature between the measuring junction and the reference junction generates a voltage that is directly related to the temperature of blackened disc which is indicated by recording instrument.

Q.2(b) Explain with neat sketch working of Mc Leod gauge. [4]

Ans.: The gas enters the gauge through the open capillary tube and fills the tubes down to the level of mercury in the reservoir. The pressure is equal through the tubes and the bulb. Mercury is pumped up from the reservoir. As the mercury raises the cut-off, it traps the gas inside the bulb. The mercury is then pumped higher in the open end capillary tube until all the gas in the bulb is compressed into the bulb. Operator allows the mercury to rise until it reaches zero reference line on the closed capillary tube. The mercury rises faster in the open capillary tube.

The compression of gas in closed capillary tube makes the pressure of trapped gas higher than the measured pressure. This pressure difference causes difference in the mercury level in the two tubes.



Mcleod Gauge

The working is based on boyles law

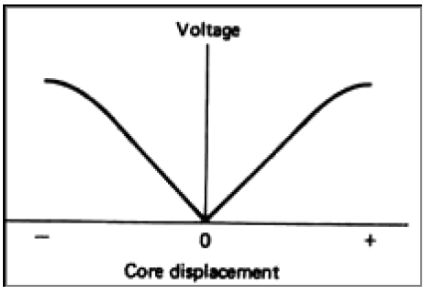
Mathematically P1V1=P2V2

Where P1=Unknown pressure of gas, V1= Initial volume of gas, P2=Final pressure, V2=Final volume of gas

P1= P2V2/ V1

Q.2(c) Draw the characteristics of LVDT and state its significance. **[4]**

Ans.:



Significance:

As the core is moved in one direction from the null position, the differential voltage i.e. the difference of the two secondary voltages will increase while maintaining an in phase relationship with the voltage from the input source. In the other direction from the null position, the differential voltage will also increase, but will be 1800 out of phase with the voltage from the source

The output voltage of an LVDT is a linear function of core displacement within a limited range of motion says about 5mm from the null position. Fig shows the variation of output voltage against displacement for various positions of core. The curve is practically linear for small displacements. Beyond this range of displacement, the curve starts to deviate from a straight line.

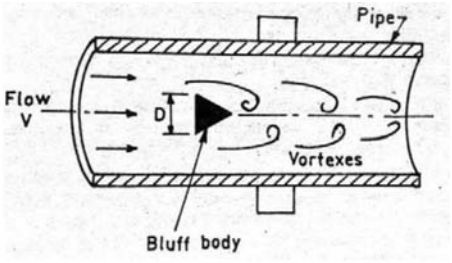
Q.2(d) Explain the working of vortex-type flow meter with a net sketch and state its advantages. **[4]**

Ans.: The principal of working of a vortex shedding flow meter is based on the fact that when a bluff is placed in a flow stream, vortices are alternately formed, first on one side of the obstruction and then on the other as shown in fig. the vortices are formed downstream when the flow impinges on the bluff body upstream. When the pipe Reynolds number R_e exceeds about 10^4, vortex shedding and the shedding frequency is given by f = (N * V) /D where, v= fluid velocity, D= characteristics dimension of bluff body, N= strouhal number.

Advantages

1) The flow meter is of portable type
2) Very low pressure loss.

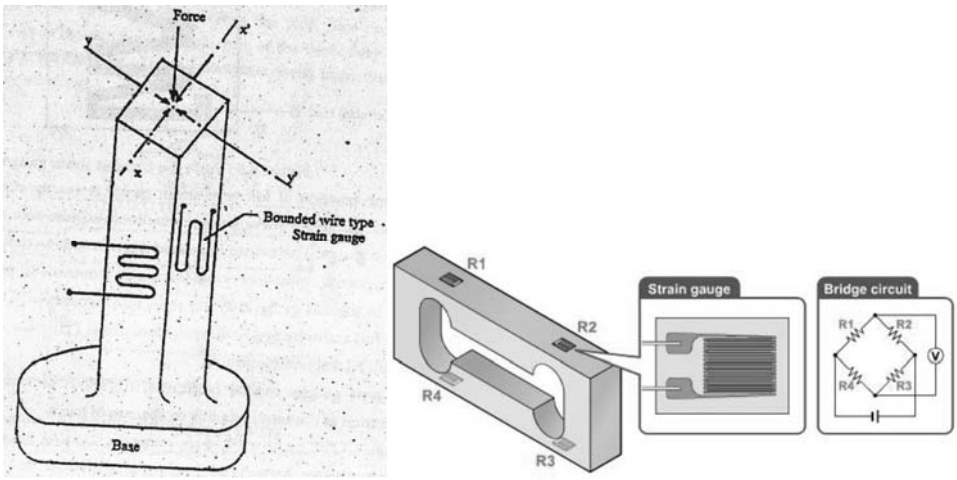
3) The instrument is very accurate and precise, the accuracy and the precision is in the range of ±5% and ±1% respectively.
4) The calibration constant is same for all fluids which include hazardous or corrosive liquid/ gases



Note: - other type of vortex flow meter (i.e swirlmeter) can be accepted

Q.2(e) Explain strain measurement method using load cell with a neat sketch. [4]

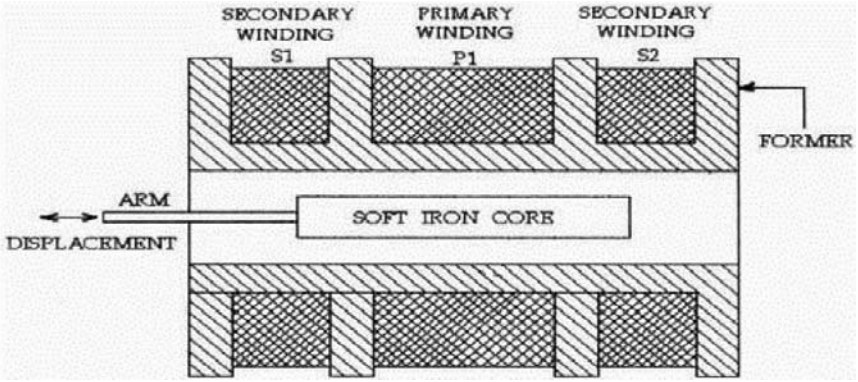
Ans.:



Load cell is application of wire type bonded strain gauge. It works on the principle of the elasticity i.e. when axial force is applied, its column gets compressed and when force is released it regain its original position .Four wire type bonded strain gauges are cemented on the column of load cell as shown in fig such that gauges along x-x are cemented in horizontal position where as along y-y in vertical position. The resistance offered by each gauge is same in magnitude. Gauges are connected to form Wheatstone bridge network. When axial force applied is zero then the resistance of each gauge is equal in magnitude, which keep bridge in balance condition and deflection shown by detector is zero. When the axial force applied is zero then the resistance of each gauge is equal in magnitude, which keep bridge in balance condition and deflection shown by detector is zero. When the axial force to be measured & resulting strain is applied on load cell then its column gets compressed. The compression of column causes decrease in resistance of strain gauge along y-y and remains unaffected along x-x. This turns the bridge to unbalance condition. The deflection shown by detector can be directly calibrated to read axial force or strain.

Q.2(f) Explain with neat sketch working principle of LVDT. [4]

Ans.: The LVDT transformer consists of a single primary winding P1 and two secondary windings S1 and S2, wound on a cylindrical former. The secondary windings have equal number of turns and are identically placed on either sides of the primary winding. The primary winding is connected to an alternating current source.



A movable soft iron core is placed inside the former. The displacement to be measured is applied to an arm attached to the soft iron core. In practice, the core is made of Ni-Fe alloy which is slotted longitudinally to reduce eddy current losses. When the core is in its normal (null) position, equal voltages are induced in the two secondary windings. Accordingly, output voltage ES1 of the secondary winding S1 is more than ES2, the output voltage of secondary winding S2. The magnitude of voltage is thus ES1- ES2 and the output voltage is in phase with ES1, the output voltage of secondary winding S1. Similarly, if a core is moved to the of null position, then the flux linking with winding S2 becomes larger than that with winding S1. This results in ES2 becoming larger than Es1. The output voltage in this case is E0 = ES2-ES1 and is in phase with ES2; i.e., the output voltage of secondary winding S2.

The amount of voltage change in either of secondary windings is proportional to the amount of movement of the core. Hence, we have an indication of the amount of linear motion. By nothing which voltage output is increasing or decreasing, we can determine the direction of motion. In other words, any physical displacement of the core causes the voltage of one secondary winding to increase while simultaneously reducing the voltage in the other secondary winding. The difference of two voltages appears across the two output terminals of the transducer and gives a measure of the physical position of the core and hence, the displacement. As the core is moved in one direction from the null position, the differential voltage i.e., the difference of two secondary voltages, will increase while maintaining an in phase relationship with the voltage from the input source.

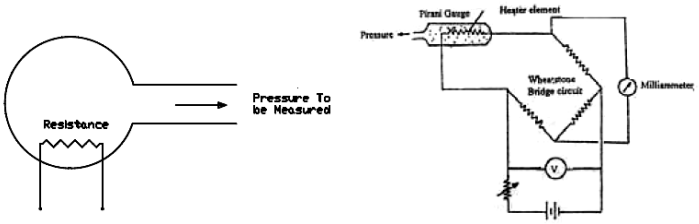
In the other direction from the null position, the differential voltage will also increase, but will be 1800 out of phase with the voltage from the source. By comparing the magnitudes and phase of the output (differential) voltage with that of the source, the amount and direction of the movement of the core and hence, of displacement, may be determined.

Q.3Attempt any FOUR of the following : [16]

Q.3(a) Explain with neat sketch 'Thermal conductivity gauge'. [4]

Ans.: Thermal conductivity Gauge; It is a low pressure measuring device. In a balanced bridge circuit four resistances are connect. One resistance is connecting to source of which pressure is to be measured. At low pressure density of gas changes and hence its ability to carry away heat is also reduced. At low pressure thermal conductivity is proportional to density hence temperature of sensing arm resistance is changed and circuit is imbalanced resulting in deflection.

Any one diagram



Q.3(b) Explain construction and working of RTD. [4]

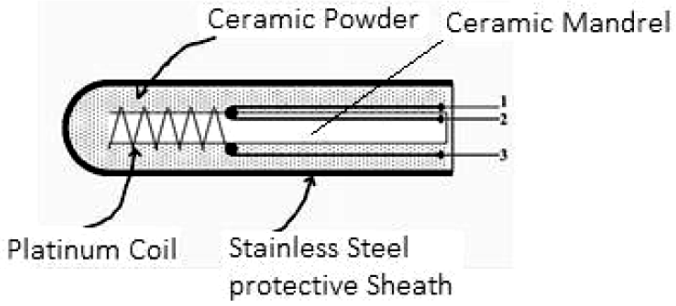
Ans.: Working Principle:

- As the temperature changes, the resistance of the conductor also changes. Resistance R in ohms of an electrical conductor of resistivity (ohms.c), length L(cm) and cross sectional area (cm2) is given by

  $R = \rho \frac{L}{A}$

- This is due to change in two factors:
  i) Dimensional change due to expansion or contraction and
  ii) Change in the current opposing properties of the material itself.

- This change in resistance due to temperature is calibrated to measure the temperature.



Construction: Figure

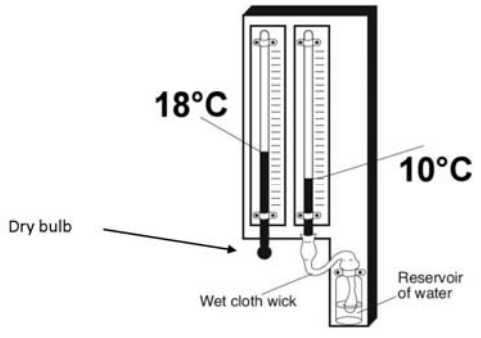
- Platinum filament is coiled on ceramic mandrel.
- Platinum is used due to its linearity with change in temperature and chemical inertness.
- Coiled platinum is protected by stainless steel metal sheath.
- Ceramic or mica powder insulates the leads.
- The leads connected in Wheatstone bridge.
- The lead wires are usually of higher diameterthan the diameter of the sensor wire to reduce the lead wire resistance.

Working:

- Steel protective sheath detects the temperature and transfer it to platinum filament.
- Temperature is sensed by platinum filament and changes its resistance.
- Change in resistance value of Platinum coil is very small with respect to the temperature. So, the RTD value is measured by using a bridge circuit.
- Temperature is determined by converting the RTD resistance value using a calibration expression.
- Dummy wire reduces impedance effect and so the error.

Q.3(c) What is psychrometer? Explain its use for measuring humidity with a neat sketch. [4]

Ans.:



PSYCHROMETER.

A psychrometer is simple type of hygrometer, an instriment that is used to measure the amount of humidity that is present in the atmosphere.

A psychrometer measures the relative humidity in the atmosphere through the use of two thermometers. The first, a dry bulb thermometer, is used to measure the temperature by being exposed to the air. The second, a wet bulb thermometer, measures temperature by having the bulb dipped in a liquid. Through the comparison of both temperatures, individuals determine the relative humidity of the surrounding area by calculating the difference between the temperatures.

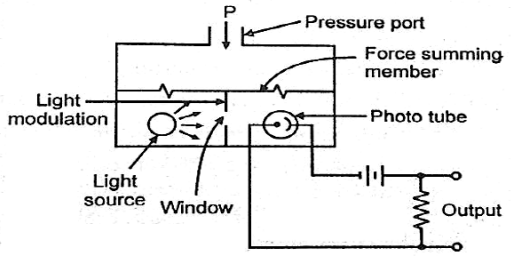
A psychrometer chart makes it easy to find the relative humidity once a reading has been taken. This reduces the need for on–the fly calculations which may be difficult to perform.

Ventilated and asporated psychrometers, which are designed to work with fans that ventilate the wet bulb thermometer. The process also increased evaporation rates evently, which produces a more accurate reading.

Used in greenhouses and industrial spaces, hygrometers are also used in some incubators (egg), humidors and museums.

Q.3(d) Explain construction and working of photo-electric pressure transducer. [4]

Ans.:



Working Principle:

Amount of incident light falling on phototube is a function of change in pressure.

Construction:Figure

- Consists of phototube and an a. c. light source separated by a small window.
- The aperture size is controlled by force summing member of pressure transducer.

Working:

- Applied pressure will be detected by force summing member.
- Applied pressure changes the position of force summing member.
- This varies the opening of window.
- Variation in opening of window causes a change in incident light on phototube.
- The change in light intensity varies photo emissive properties at a linear rate with displacement.

Q.3(e) Distinguish between Non-electrical methods and Electrical methods for temperature measurements. [4]

Ans.: Temperature Measurement

Non Electrical Methods	Electrical Methods
Does not require electrical power	Require external source to operate the instrument
Output signal is analog form	Output is in digital form
Temperature range is limited to 600o C	Higher Temperature range i limited to 600° C to 2000°
Example Bimetallic Thermometer, Liquid in glass etc	Example RTD, Thermocouple, Thermistor, Pyrometers

Q.3(f) Differentiate between deflection and null-output type measurement instruments and give its appropriate examples. **[4]**

Ans.:

Null type instrument	Deflection type instrument
The physical effect caused by the quantity being measured is nullified by generating an equivalent opposing effect.	The physical effect generated by the measuring quantity is noted and correlated to the measurand.
e.g. pan balance or dead weight gauge. In this balanced condition indicated by zero or null position	e.g. platform scale, pressure gauge. In this weight of object is indicated by the relative displacement between pointer and dial.
Null type devices are slow in operation and have poor dynamic response.	Simple in construction and operation and have good dynamic response.
More accurate and sensitive.	Comparatively less sensitive.
Do not interfere with the state of quantity being measured.	They interfere with the state of measurand and do not determine its exact state/value/condition.

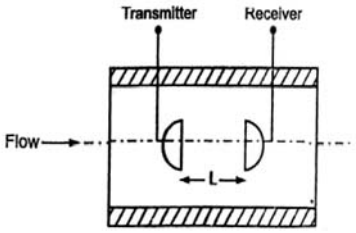
Q.4Attempt any FOUR of the following : **[16]**

Q.4(a) List various advantages of electromagnetic flowmeter. **[4]**

Ans.:
1. It can handle slurries and greasy materials.
2. It can handle corrosive fluids.
3. It has very low pressure drop.
4. It is totally obstruction less.
5. Available in several construction materials.
6. Available in large pipe size and capacities.
7. Measurement unaffected and change in density, pressure, temperature etc.
8. Capable of handling extremely low flow rates or very high flow rates.
9. Voltage o/p is proportional to average velocity and does not depend on whether flow is laminar or turbulent.

Q.4(b) Draw neat sketch of Ultrasonic Flow Meter and explain how flow is measured by it. **[4]**

Ans.:



Ultrasonic Flow measurement

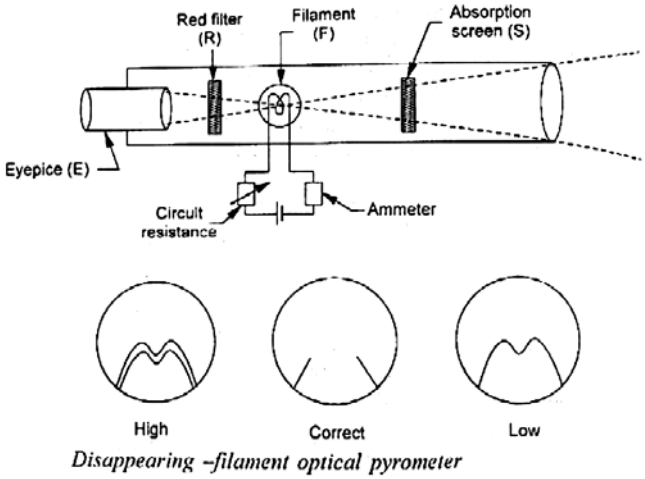
Ultrasonic flow meters measure the difference of the transit time of ultrasonic pulses propagating in and against flow direction. This time difference is a measure for the average velocity of the fluid along the path of the ultrasonic beam. By using the absolute transit times both the averaged fluid velocity and the speed of sound can be calculated. Using the two transit times and the distance between receiving and transmitting transducers.

An **ultrasonic flow meter** is a type of that measures the velocity of a fluid with ultrasonic flow meter to calculate volume flow. Using ultrasonic transducers, the flow meter can measure the average velocity along the path of an emitted beam of ultrasound, by averaging the difference in measured transit time between the pulses of ultrasound propagating into and against the direction of the flow or by measuring the frequency shift from the Doppler

effect. Ultrasonic flow meters are affected by the acoustic properties of the fluid and can be impacted by temperature, density, viscosity and suspended particulates depending on the exact flow meter.

Q.4(c) Explain with a neat sketch, working of optical pyrometer for temperature measurement. [4]

Ans.: Optical Pyrometer



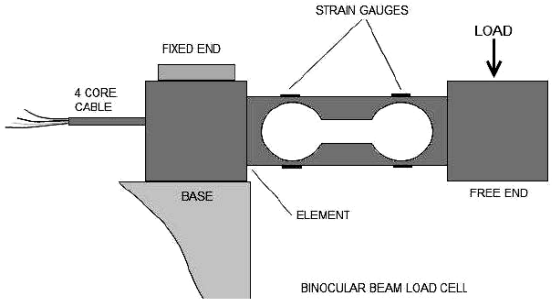
Disappearing –filament optical pyrometer

Principle: Moncromatic radiation wavelength of a fixed color from a hot surface of body whose temperture is to be measured, is compared with a standard filament light wavelength.

Working: The current through the lamp filament is made variable so that lamp intensity can be adjusted. The filament is viewed the eyepiece and filter. The current through the filament is so adjusted tht filament and image are of equal brightness. When brightness of source and image produced is same, we can say that both temepratures are same.
If the temperature of filament is higher than that required for equal brightness, filament become too bright as show in figure. (High). And if the temperature of filament is lower, it becomes too dark as shown in figure (Low).
Range - 1400°C, can be incresed upto 3000°C.

Q.4(d) Explain with neat sketch how Load Cell is used for strain measurement. [4]

Ans.: Load Cell and Strain Measurement



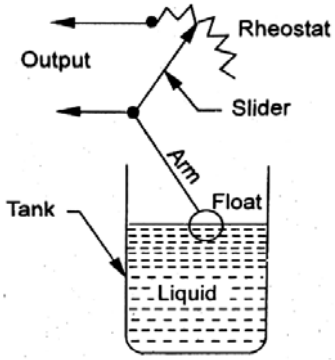
Load cell is application of wire type strain gauge .
It works on the principle of the elasticity i.e. when axial force is applied, its column gets compressed and when force is released it regain its original position. Four wire type bonded strain gauge are cemented of the column of the load cell .when it is used for measurement of axial force or strain gauges are connected to form Wheatstone bridge network.

When the axial force to be measured is applied on load cell then its column gets compressed. The compression of the column causes decease in resistance at the strain gauge .this turns the bridge to unbalance condition. The deflection shown by detector can be directly calibrated to read axial force.

Q.4(e) Explain float and resistance type instrument used for liquid level measurement. [4]

Ans.: Working principle:

Change in the float level moves the slider over a rheostat causing change in resistance. This change in resistance is calibrated as the liquid level.



Construction:

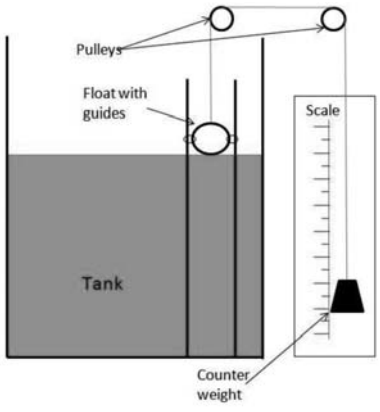
Consists of float whose arm is connected to slider of rheostat.
Arm of a float and slider forms a lever as shown in figure.

Working:

When the liquid level changes it moves the float up and down.
Float displacement actuates slider to slide over the resistance coil of rheostat,
This changes the length of resistance coil in the circuit changing the value of resistance.
This change in resistance changes the output current which is calibrated as the liquid level.

Q.4(f) Explain with a neat sketch, working of float type gauge for measuring liquid level of tank. [4]

Ans.:



Float type gauge

Working:

There are two types of float type gauges.
Float and tape system 2. Wire guided float detectors.
Common level measuring system uses a tape or servo motor which is connected to a float.
The height can be read as float moves with liquid level.
Float devices use the buoyancy of a float to indicate the liquid level in the tank. The chain is attached to a counter weight which indicates the level as the float moves up and down.
A magnetic level gauge is used where the liquid is corrosive, toxic or in way hazardous.

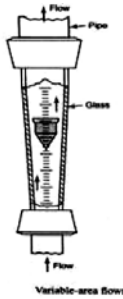
Q.5Attempt any FOUR of the following: [16]

Q.5(a) Explain the working of Rotameter with the help of neat diagram. [4]

Ans.:

- The basic construction of a rotameter is shown in fig.It consists of a vertical pipe, tapered downward. The flow passes from the bottom to the top.
- There is cylindrical type metallic float inside the tube.
- The fluid flows upward through the gap between the tube and the float.

- As the float moves up or down there is a change in the gap, as a result changing the area of the orifice.
- In fact, the float settles down at a position, where the pressure drop across the orifice will create an upward thrust that will balance the downward force due to the gravity. The position of the float is calibrated with the flow rate.

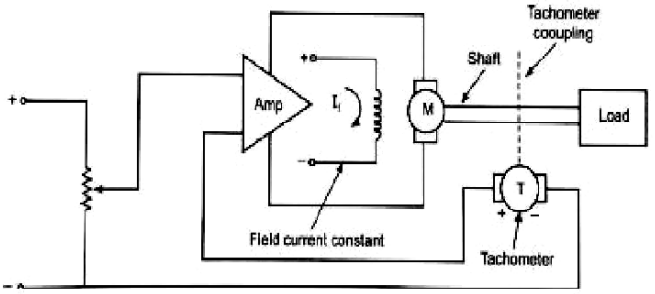


Variable-area flowmeter.

Q.5(b) Explain control system used for motor speed control. **[4]**

Ans.: Control system used for motor speed control:

- The D.C. shunt motor is used where the field current is kept constant and armature voltage is changes to obtain desired speed. The feedback is taken by speed tachometers.
- This generates voltage proportional to speed which is compared with voltage required to the speed.
- This difference is used to change the input to the controller which cumulatively changes the speed of the motor as required.



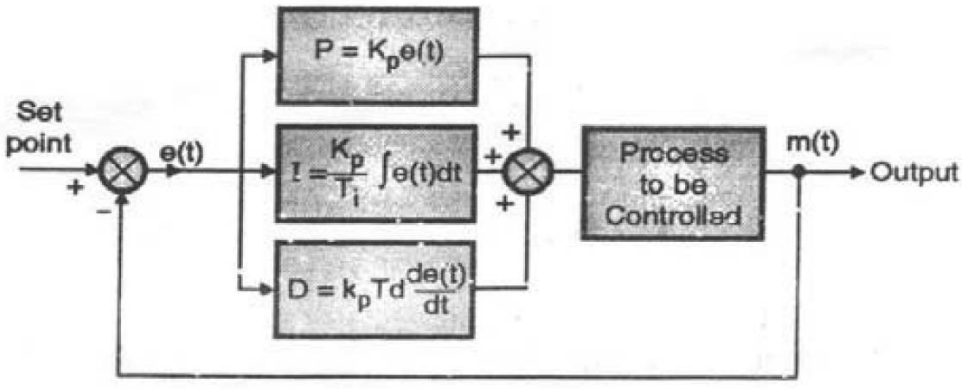
Q.5(c) With a neat sketch, explain working of PID control system. **[4]**

Ans.: PID Control Action

It is the composite control action of proportional integral and derivative control mode. It combines the advantages of these three control actions. In this system the output (m) is a linear combination of input e, the time rate change of input and the time integral as input . Mathematically it is given by

$$m(t) = K_p\, e(t) + \frac{K_p}{T_i}\int e(t).dt + K_p T_d \frac{de(t)}{dt} + M \ldots (IV)$$

The PID control mode is best suitable for system where close controls is required because of large and sudden fluctuations



Q.5(d) How flow is measured by Hot wire Anemometer? [4]

Ans.:

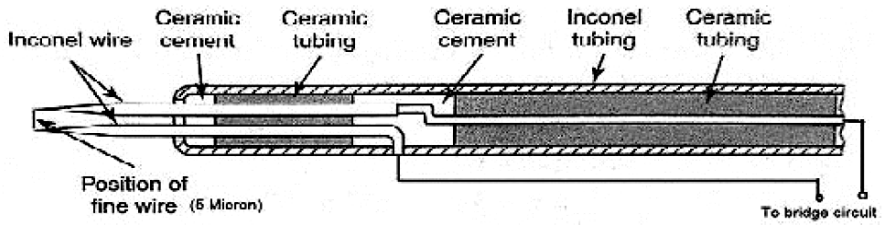


Figure show the construction of hot wire anemometer.

The sensor is a 5 micron diameter platinum-tungsten (Inconel) wire welded between two prongs of the probe and heated electrically as a part of Wheatstone bridge circuit.

When probe is introduced into flowing fluid, it tends to be cooled by instantaneous velocity and hence there is change in electrical resistance of fine wire.

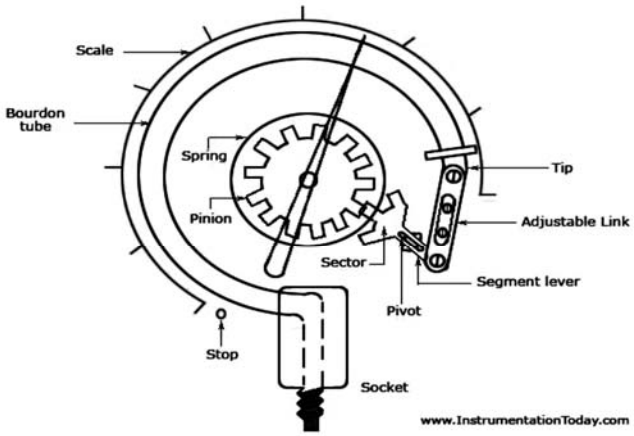
The rate of cooling depend upon

i) Dimensions and physical properties of wire
ii) Difference of temperature between the wire and fluid
iii) Physical properties of the fluid
iv) Stream velocity under measurement.

For a simple hot wire anemometer first three conditions are effectively constant and the instrument response is then direct function of the velocity.

Q.5(e) Explain with a neat sketch, working of Bourdon-Tube pressure gauge. [4]

Ans.:



Bourdon Tube Pressure Gauge

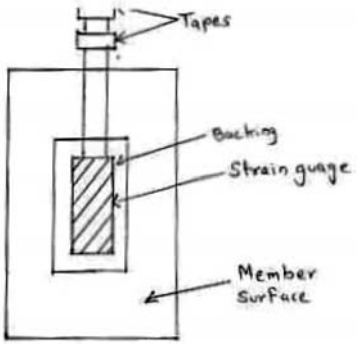
An elastic transducer that is bourdon tube which is fixed and open at one end to receive the pressure which is to be measured. The other end of the bourdon tube is free and closed. To the free and of the bourdon tube is attached an adjustable link which in turn connected to a sector and pinion. To the shaft of a pinion is connected a pointer which sweeps over a pressure calibrated scale.

The pressure to be measured is connected to the fixed open end of the bourdon tube. The applied pressure act on the inner walls of the bourdon tube. Due to the applied pressure the bourdon tube tends to change in cross section from elliptical to circular. This tends to straighten the bourdon tube causing a displacement of the free end of the bourdon tube.

This displacement of the free closed end of the bourdon tube is proportional to applied pressure. As the free end of the bourdon tube is connected to a link section pinion arrangement, the displacement is amplified and converted to a rotary motion of the pinion. As the pinion rotates; it makes the pointer to assure a new position on a pressure calibrated scale to indicate the applied pressure directly.

Q.5(f) Explain bonded type of strain gauge with neat sketch. **[4]**

Ans.: Bonded type Strain Gauge :



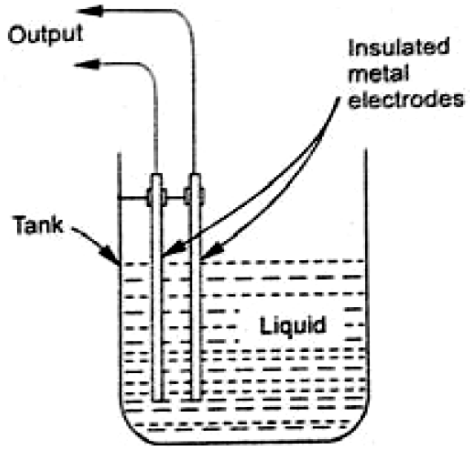
- Bonded strain gauges are metallic or semiconductor filaments cemented on a paper backing or epoxy resin backing. These gauges(metallic or semiconductor) are bonded or cemented directly onto the surface of structural member which is being examined.
- Strain gauge filaments forms the four resistances of Wheatstone bridge circuit. Any deflection/deformation of structural member on which the strain gauges are mounted, will result the change in length of any one or all the four resistances of Wheatstone bridge circuit.
- This change in resistance can be calibrated to measure the strain or the measured.
- **Applications:** i) Determination of maximum stress values. ii) Force/ Thrust measurement,e.g. Load cells iii) Pressure Measurement iv) Torque measurement e.g. strain gauge torsion meter. v) For experimental verification of strain in complex physical systems

Q.6Attempt any FOUR of the following: **[16]**

Q.6(a) Explain with neat sketch the working of capacitive transducer for liquid level measurement. **[4]**

Ans.: Figure shows the capacitive liquid level transducer.

- Two parallel insulated metal electrodes are firmly at a known fixed distance apart. The dielectric constant between the electrodes varies with the liquid level and so the capacitance of the system.
- Change in capacitance is calibrated to measure the liquid level.



Q.6(b) Write the principle of turbine meter with two applications. **[4]**

Ans.: Turbine Flow meter

Construction and working

The turbine flow meter consists of a multi blade rotator which is placed at right angle to the axis of flowing fluid. The rotor is supported by ball bearing on a shaft. This is free to rotate about its axis. A magnetic pickup coil is placed near the table. It is used to measure the speed of blade.

The turbine flow meter works on basic principle of turbine. If is losses are kept minimum, the turbine speed varies linearly with flow rate i.e. flow rate can be measured by measuring the speed of the turbine. When blade passes by pickup coil it interrupt magnetic field and produces a pulse. The rate of pulse gives flow and total number of pulses gives a measures of the flow. Turbine meter is shown in Fig

Q.6(c) A pressure gauge having a range of 500 kN/m^2 has a guaranteed accuracy of 1.5% of full scale deflection. What would be the possible readings for a true value of 95 kN/m^2? [4]

Ans.: Given Data: Range: o to 500 KN/m^2
Span= 500 – 0 = 500 KN/m^2
&
Accuracy: 1.5% of FSD

To find: Possible reading for a true value of 95 KN/m^2

Solution:

Step 1) Maximum Limiting Error = [Fractional form of accuracy x span of instrument]
= [0.015 x 500] KN/m2 =7.5 KN/m2

Step 2) Possible reading for true value = [95±7.5] KN/m2
= 87.5 KN/m2 & 102.5 KN/m2

Q.6(d) What are the different control actions? State its significance. [4]

Ans.: Different modes of control action:

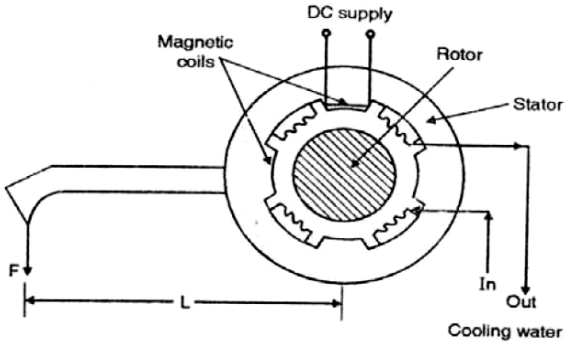
- On-off control
- Proportional control
- Proportional plus integral control
- Proportional plus derivative control
- Proportional plus integral plus derivative control

Significance: 1) Suitable for P, PI, PD, PID control. 2) Suitable for manual control.
3) Multiples I/P & O/P. 4) Transient control.

Q.6(e) Explain principle of eddy current dynamometer with neat sketch. [4]

Ans.: Eddy current is the type of absorption type dynamometer is used for shaft power measurement

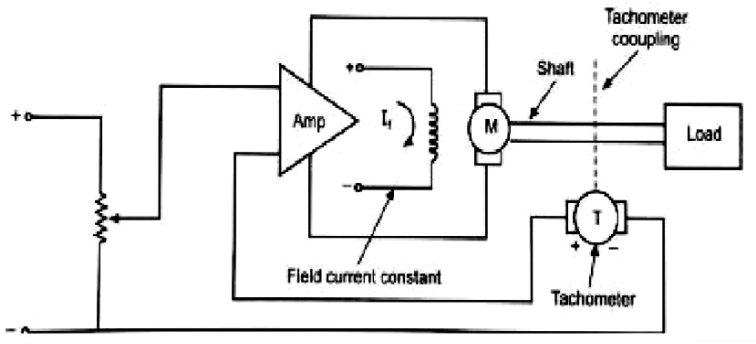
- It consists of non-magnetic solid metallic rotor, which moves in the magnetic field of stator.
- The stator winding is excited by a D.C. supply as shown in fig



- When the soild rotor moves in the field produced by stator windings an emf is produced in it resulting in a large loss of power due to eddy current.
- This power is dissipated as heat in the rotor and therefore water is circulated through air gap between stator and rotor.

Q.6(f) Explain servo motor mechanism with neat sketch. State its application. [4]

Ans.: Servo motor mechanism:



It is employed to provide a position output proportional to input electrical signal. The stator has two distributed windings which is called reference winding and control winding. The main winding (also called the reference or fixed phase) is supplied from a constant voltage source of 110 V and 50 Hz.

The other winding (also called the control phase) is supplied with a variable voltage of the same frequency as the reference phase but is phase-displaced by 90° (electrical). The control- phase voltage is controlled by an electronic controller. The speed and torque of the rotor are controlled by the phase difference between the main and control windings. Reversing the phase difference from leading to lagging (or vice-versa) reverses the motor direction. Since the rotor bars have high resistance, the torque-speed characteristics for various armature voltages are almost linear over a wide speed range particularly near the zero speed. The motor operation can be controlled by varying the voltage of the main phase while keeping that of the reference phase constant. Importance of servo mechanism in control system

- A servomotor is a rotary actuator that allows for precise control of angular position, velocity and acceleration
- They are small in size but pack a big punch and are very energy efficient.

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