18ME703

Hall Ticket Number:

IV/IV B.Tech (Regular/Supplementary) DEGREE EXAMINATION

November, 2022 — **Mechanical Engineering**

Seventh Semester — **Instrumentation and Control Systems**

Time: Three Hours — **Maximum:** 50 Marks

Answer Question No.1 compulsorily. (10X1 = 10 Marks)

Answer ONE question from each unit. (4X10=40 Marks)

1.	a)	Explain your understanding on calibration of measurement system.	CO1	L2	
	b)	Distinguish between active and passive transducers.	CO1	L1	
	c)	Explain sensors in measurement	CO1	L3	
	d)	Write short notes on thermistors.	CO2	L4	
	e)	Explain the principle of thermocouple.	CO2	L1	
	f)	List out different instruments for high pressure measurement.	CO2	L1	
	g)	Write short notes on cryogenic fuel level indicator	CO3	L2	
	h)	State advantages and limitations of a rotameter.	CO3	L3	
	i)	Classify shaft power measurement techniques	CO4	L1	
	j)	What are the basic elements of a control system	CO4	L1	
		Unit -I			
2.	a)	List and Define different static characteristics of a measurement system.	CO1	L2	5M
	b)	Explain with a neat sketch construction and working of a LVDT.	CO1	L3	5M
		(OR)			
3.	a)	Derive, from first principle, the relationship for gauge factor of a strain gauge.	CO1	L1	5M
	b)	Define Strain rosette. Classify strain rosette. How it is used for strain measurement.	CO1	L4	5M
		Unit -II			
4.	a)	Classify temperature measuring instruments and explain working of bi-metallic strip thermometer for the measurement of temperature.	CO2	L2	5M
	b)	Explain principle and operation of optical pyrometer with neat sketch?	CO2	L2	5M
		(OR)			
5.	a)	Sketch and explain bellows pressure gauge for the measurement of differential pressure.	CO2	L1	5M
	b)	Sketch & Explain Mc.Loed gauge for measurement of Vacuum.	CO2	L3	5M
		Unit -III			
6.	a)	Explain the working principle of Capacitance liquid level sensor.	CO3	L2	7M
	b)	List out the disadvantages of liquid level measurement by resistive method.	CO3	L3	3M
		(OR)			
7.	a)	Explain the Construction, working and applications of Magnetic flow meter.	CO3	L3	4M
	b)	With the help of hot wire bridge circuit explain the working of hot wire anemometer in constant current mode and constant temperature mode.	CO3	L2	6M
		Unit -IV			
8.	a)	How does a pneumatic load cell work? Explain the principle of measuring force using pneumatic load cell?	CO4	L4	6M
	b)	Describe the constructional and operation of hydraulic dynamometer with a neat sketch.	CO4	L1	4M
		(OR)			
9.	a)	Discuss advantages and disadvantages of open loop and closed control systems?	CO4	L1	5M
	b)	Describe servo mechanism. Draw block diagram of a servo mechanism.	CO4	L2	5M

IV/IV B.Tech (Regular/Supplementary) DEGREE EXAMINATION

November, 2022 — **Mechanical Engineering**

Seventh Semester — **Instrumentation and Control Systems**

Scheme of Evaluation

10 X 1 = 10 Marks

1. **A)** Calibration is a comparison between a known measurement (the standard) and the measurement using your instrument. Typically, the accuracy of the standard should be ten times the accuracy of the measuring device being tested.

   B) An active transducer can be defined as, a transducer which gives the output in different forms like current or voltage without using any exterior source of energy. The passive transducer can be defined as the internal parameters of transducer like resistance-capacitance as well as inductance are changed due to the input signal.

   C) A Measurement Sensor is a device that measures the dimensions of an object by converting changes in amount of light into electrical signals when the object interrupts a wide laser beam.

   D) A thermistor is a resistance thermometer, or a resistor whose resistance is dependent on temperature. The term is a combination of "thermal" and "resistor". It is made of metallic oxides, pressed into a bead, disk, or cylindrical shape and then encapsulated with an impermeable material such as epoxy or glass.

   E) The thermocouple can be defined as a kind of temperature sensor that is used to measure the temperature at one specific point in the form of the EMF or an electric current.

   F) 1. The Barometer 2.Piezometer or Pressure Tube 3. Manometers 4. The Bourdon Gauge 5. The Diaphragm Pressure Gauge

   G) A cryogenic tank contains multiple sensors on the interior. These sensors play an important role in detecting the amount of fluids that are present within the tank itself. The level indicator is located on the control panel of the cryogenic tank – and the sensors connect to this particular part of the tank.

   H) The cost of rotameter is low, It provides linear scale, It has good accuracy for low and medium flow rates, The pressure loss is nearly constant and small, Usability for corrosive fluid.

   The rotameter is used in process industries, for monitoring gas and water flow in plants or labs,It is used for monitoring filtration loading.

   I) Torision dynamometer, Strain gauge dynamometer, Hydraulic and Electrical dynamometer.

   J) There are four basic elements of a typical motion control system. These are the controller, amplifier, actuator, and feedback.

Unit -I

2. a) List and Define different static characteristics of a measurement system.

   1. Accuracy: It is the degree of closeness of readings from an instrument to the true value. Always accuracy is measured relative to the true value or actual value.
   2. Sensitivity: It refers to the least change in measured value to which instrument or device responds. The ratio of change in the output of an instrument to a change in the value of the quantity to be measured is known as sensitivity.
   3. Precision: It is the degree of closeness of reading with the previous reading. An instrument is said to be precise when there is negligible difference between successive readings.
   4. Linearity: The linearity is defined as the ability to give the input characteristics symmetrically and linearly (Straight line). In other words, the ability to measure maximum deviation from the ideal linear line. Instruments are said to be linear when there is an increment in input and output are constant over the specified range.
   5. Resolution: It refers to a small change in input value does not affect the output value of an instrument. This continues until both the increment value and output value exceed the threshold value. This increment is called a resolution.
   6. Repeatability: It defines how consistent is the output of an instrument for the same input tried again and again under the same conditions.
   7. Range: The left extreme and right extreme values of a quantity for which the instrument is designed to function. The range is equal to Maximum value minus minimum value.
   8. Tolerance: It is the highest allowable error that is specified in terms of certain values while measurement, it is called tolerance.
   9. Hysteresis: It is defined as an instrument showing different output values during loading and unloading conditions.

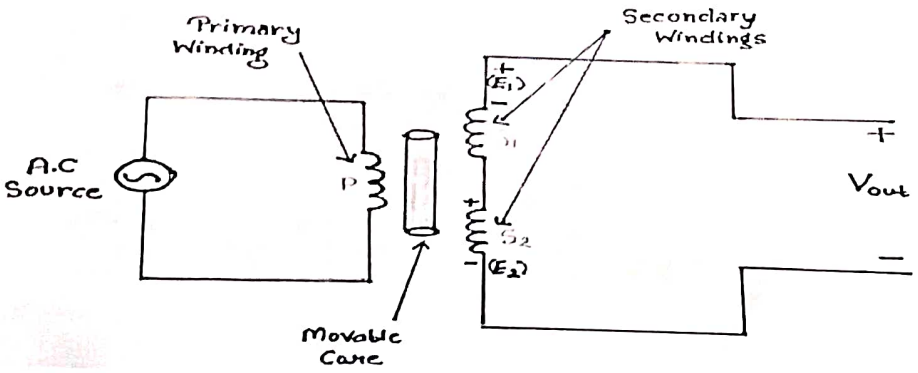
   — 5 M

   b) Explain with a neat sketch construction and working of a LVDT.

   LVDT stands for Linear Variable Differential Transformer. It is an important type of inductive transducer; those transducers that work on the principle of transduction mechanism are known as inductive transducers. The structure of LVDT is similar to the transformer; it consists of one primary winding, i.e., P

and two secondary windings, i.e., S1 and S2. The primary and secondary windings are wounded on a ho cylindrical shaped structure, called former. The former is usually made of glass-reinforced polymer wrap in a highly permeable material and then covered with cylindrical steel. The primary winding is at the centre the cylindrical former and the secondary windings are present on both sides of the primary winding at a equal distance from the centre. Both the secondary windings consist of an equal number of turns, and they are linked with each other in series opposition, i.e., they are wounded in opposite directions but are connected in series with each other. The working of LVDT is based on the principle of Faraday's law of electromagnetic induction that states that "the net induced emf in the circuit is directly proportional to the rate of change of magnetic flux across the circuit, and the magnetic flux of the coil wounded with wires can be changed by moving a bar magnet through the coil."As the primary winding of the LVDT is connected to the AC power supply, the alternating magnetic field is produced in the primary winding, which results in the induced emf the secondary windings. Let us assume that the induced voltages in the secondary windings S1 and S2 be E1 and E2 respectively. Now, according to Faraday's Law, the rate of change of magnetic flux, i.e., dØ/dt is directly proportional to the magnitude of induced emf's, i.e., E1 and E2. Hence, the induced emf in the secondary windings will be more if the value of 'dt' will be low (dØ/dt ∝ E1 and E2), and the low value of 'dt' implies that the soft iron core present inside the LVDT is moving faster. Thus, emf of large magnitude will induce in the secondary windings S1 and S2 if the movement of the core is faster inside the LVDT.

— 3 M



— 2M.

3. A) Derive, from first principle, the relationship for gauge factor of a strain gauge.

$R = \frac{\rho L}{A} = \frac{\rho L}{CD^2} \rightarrow (1)$ L = length, ρ = Resistivity of material, A = cross area, $C = \frac{\pi}{4}$, $\epsilon = 1$.

$dR = \frac{CD^2(L d\rho + \rho dL) - 2\rho L D dD}{CD^2}$

$= \frac{1}{CD^2}(L d\rho + \rho dL) - 2\rho L \frac{dD}{D}) \rightarrow (2)$

dividing eq'n (2) by (1)

$\frac{dR}{R} = \frac{dL}{L} - 2\frac{dD}{D} + \frac{d\rho}{\rho} \rightarrow (3)$

$\frac{dR}{R} / \frac{dL}{L} = 1 - 2\frac{dD/D}{dL/L} + \frac{d\rho/\rho}{dL/L}$

$\frac{dL}{L} = \epsilon_a$ = axial strain

$\frac{dD}{D} = \epsilon_L$ = lateral strain

υ = Poisson's ratio = $-\frac{dD/D}{dL/L}$

$F = \frac{dR/R}{\frac{dL}{L}} = 1 + 2\upsilon + \frac{d\rho/\rho}{dL/L}$

Where F is called Gauge factor

— 5M

B) Define Strain rosette. Classify strain rosette. How it is used for strain measurement.

A strain gauge rosette is a term for an arrangement of two or more strain gauges that are positioned closely to measure strains along different directions of the component under evaluation. These strain gauges are used to measure the normal strain in those three directions. Depending on the arrangement of strain gauges, strain rosettes are classified in to:- 1. Rectangular strain gauge rosette 2. Delta strain gauge rosette 3. Star strain gauge rosette

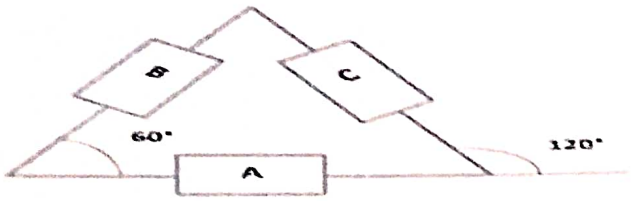
— 2M

Rectangular strain gauge rosette

A rectangular strain rosette consists of three strain gauges arranged as follows:-

Delta strain gauge rosette

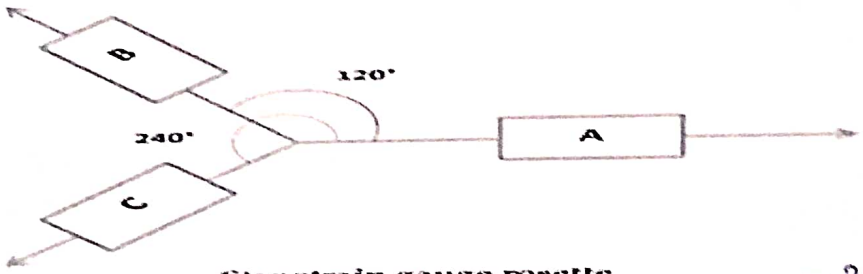
A delta strain gauge also consist of three strain gauges arranged as shown below



Delta strain gauge rosette

Star strain gauge rosette

This rosette consist of three strain gauges in three directions as shown below



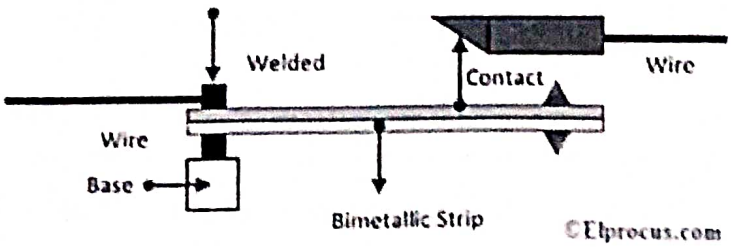
Star strain gauge rosette — 3M

Q. A) Classify temperature measuring instruments and explain working of bi-metallic strip thermometer for the measurement of temperature.

A thermometer which uses two different metal strips for converting the displacement of temperature into mechanical. The metals used in the thermometer are steel, copper & brass. These strips are connected and they will enlarge at different rates once they heated. This change will compare with the real temperature & moves a needle beside the scale. These thermometers are low-cost, simple, and strong. The bimetallic thermometer diagram is shown below.

The working principle of this thermometer mainly depends on two basic temperature properties of the metal like the following. Once the temperature changes, then there will be a change in the physical dimension of the metals. Whenever the temperature rises, the metal strip turns in the direction of the less temperature coefficient metal. Similarly, when the temperature reduces, then the strip turns in the direction of a high-temperature coefficient metal.

— 3M



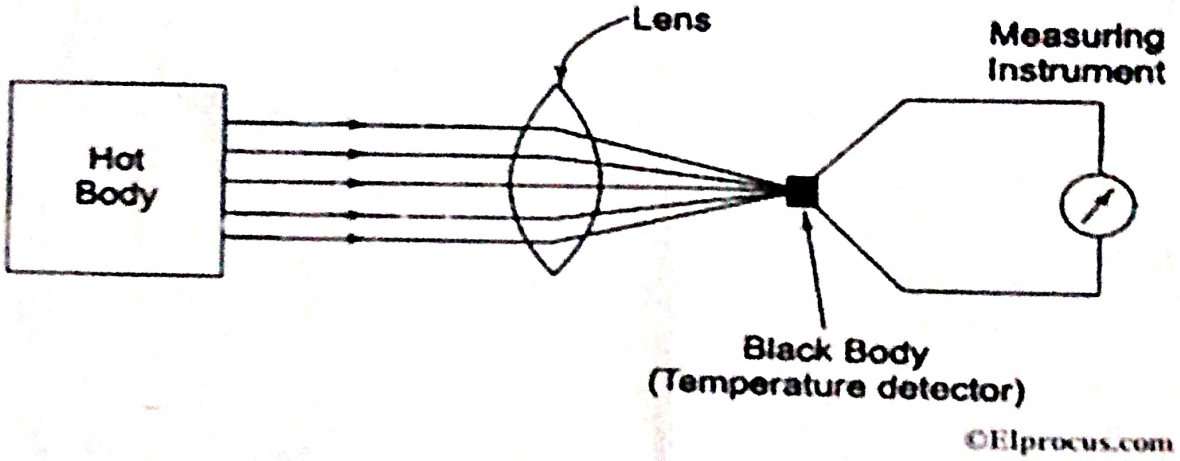
— 2M

Advantages of Bimetallic Thermometer

The advantages are Installation is easy Simple maintenance, Accuracy is good,Less cost, Temperature range is wide, Linear response, Robust and simple

b) Explain principle and operation of optical pyrometer with neat sketch?

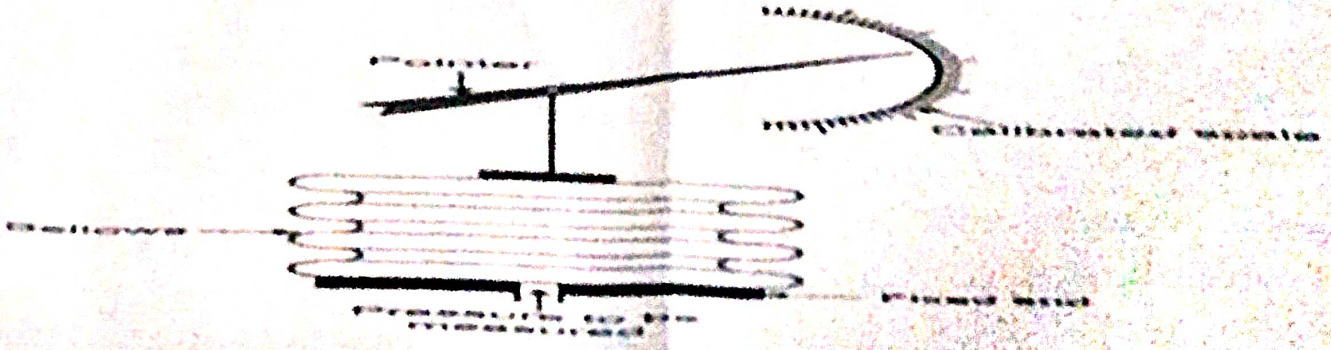
Pyrometer also is known as an Infrared thermometer or Radiation thermometer or non-contact thermometer used to detect the temperature of an object's surface temperature, which depends on the radiation (infrared or visible) emitted from the object. Pyrometers are the temperature measuring devices used to detect the object's temperature and electromagnetic radiation emitted from the object. These are available in different spectral ranges. Based on the spectral range, pyrometers are classified into 1-color pyrometers, 2-color pyrometers, and high-speed pyrometers.
The basic principle of the pyrometer is, it measures the object's temperature by sensing the heat/radiation emitted from the object without making contact with the object. It records the temperature level depending upon the intensity of radiation emitted. The pyrometer has two basic components like optical system and detectors that are used to measure the surface temperature of the object. When any object is taken whose surface temperature is to be measured with the pyrometer, the optical system will capture the energy emitted from the object. Then the radiation is sent to the detector, which is very sensitive to the waves of radiation. The output of the detector refers to the temperature level of the object due to the radiation. Note that, the temperature of the detector analyzed by using the level of radiation is directly proportional to the object's temperature.



5. Sketch and explain bellows pressure gauge for the measurement of differential pressure.

a)

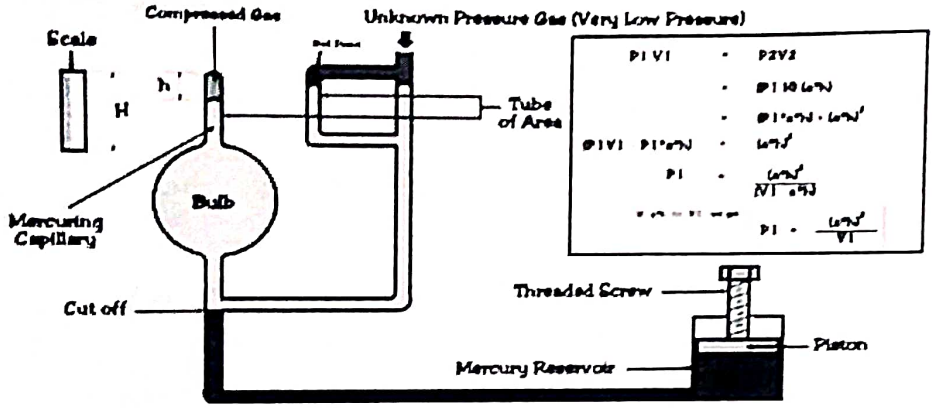
The bellow type pressure gauge consists of thin-walled metallic discs with concertinaed sides to allow it to expand and contract, with one end closed and the other end remains open. When the pressure is applied from the open side of the bellows, it expands the size of discs. The closed-end moves freely and the rod connected between the open end and the closed-end move upwards and rotate the pointer which will show the value of pressure. Most bellow gauges are spring-loaded. The spring opposes the bellow and preventing it from full expansion. The limiting of full expansion of the bellow protects it and prolongs its life. In a spring-loaded bellow element, the deflection is the result of the force acting on the bellows and opposing the force of the spring.



5) Sketch & Explain Mc.Loed gauge for measurement of Vacuum.

A Mcleod gauge is a device used to measure very low pressures at approximately 10^{-6} torr. The device is named after its inventor, Herbert Mcleod. It was invented by Herbert McLeod in the year 1874. The size of the mac load gauge is similar to that of a mercury manometer which is the most common instrument used for the measurement of pressure. This Mcleod gauge also has mercury inside it, and the pressure measurement is done by observing changes in the mercury level. The known volume of the gas is compressed into a small volume whose final value provides an indication of the applied pressure. The Mcleod gauge works on the principle of Boyle's law. Boyle's law states that if the temperature and volume of gas remain unchanged, the absolute pressures exerted by a given mass of gas are inversely proportional to its volume. According to Boyle's law: P1V1 = P2V2

– 2M

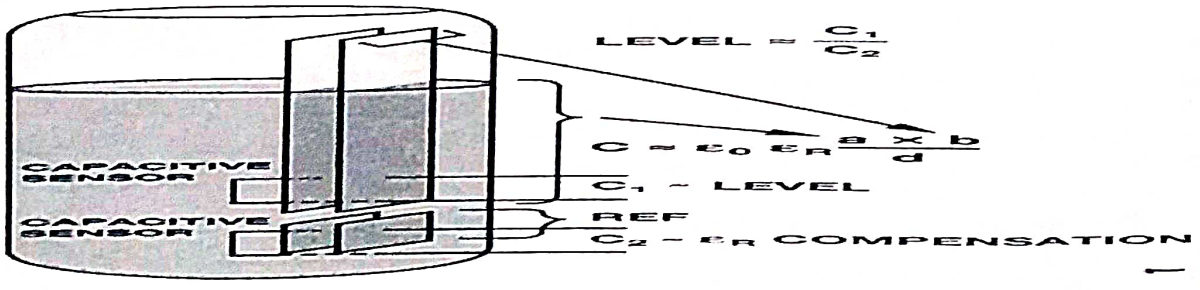


– 3M

The Macleod gauge works by taking a sample of the gas from the vacuum chamber and then tilting it and infecting it with mercury. As in this Mcleod gauge, the pressures are calculated using Boyle's law. Therefore, we must first pressurize a known amount of gas. So the pressure we want to measure, or the initial pressure (P1), is applied at the top of the reference column. The mercury levels are raised by pressing the piston down. As the pistons are pressed down, the mercury level in the mercury reservoir decreases, and the level of mercury in the measuring capillary increases. The level of mercury in measuring capillary is brought just below the cut-off point, & at this point, the applied pressure fills the bulb & capillary.

6. a) Explain the working principle of Capacitance liquid level sensor.

The principle of capacitive level measurement is based on the capacitance change of a capacitor. The probe and the tank wall form a capacitor whose capacitance is dependent on the amount of product in the tank: An empty tank has a lower, a filled tank a higher capacitance.



– 4M

The Capacitive liquid level sensor is used to measure the change of capacitance to measure the level of the liquid level. The capacitive liquid level sensor is used to measure the change of capacitance to measure the unevenness of the liquid level. The capacitive liquid level sensor is a metal rod pierced into the liquid container. The metal rod serves as a pole of the capacitor. The container wall serves as the other pole of the capacitor. The medium between the two electrodes is the liquid and the gas above it.

– 3M

b) List out the disadvantages of liquid level measurement by resistive method.

Unsafe to use this transducer in explosive atmosphere due to arcing at the contact points, Large number of contact rods are required, The contact rods are corroded by corrosive liquids.

– 3

7. a) Explain the Construction, working and applications of Magnetic flow meter.

Magnetic Flow Meters are the first type of flowmeters to be considered for high corrosive applications and for applications involving measurement of erosive slurries. These meters work on the principle of Faraday's law of electromagnetic induction, which states that whenever a conductor moves through a magnetic field of given field strength, a voltage is induced in the conductor proportional to the relative velocity between the conductor and the magnetic field. The Magnetic Flow Meters consists of an electrically insulated or non conducting pipe, such as fibre glass, with a pair of electrodes mounted opposite each other and flush with the inside walls of the pipe, and with the magnetic coil mounted around the pipe so that a magnetic field is generated in a plane mutually perpendicular to the axis of the flow meter body and to the plane of the electrodes. If a metal pipe is used, an electrically insulating liner is provided on the inside of the pipe.

Advantages of Magnetic Flow meter:

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. It is available in large pipe sizes and capacity as well as in several construction materials.

Disadvantage of Magnetic Flow meter:

1. It is relatively expensive.
2. It works only with fluids which are adequate electrical conductors.
3. It is relatively heavy, especially in larger sizes.

— 2M

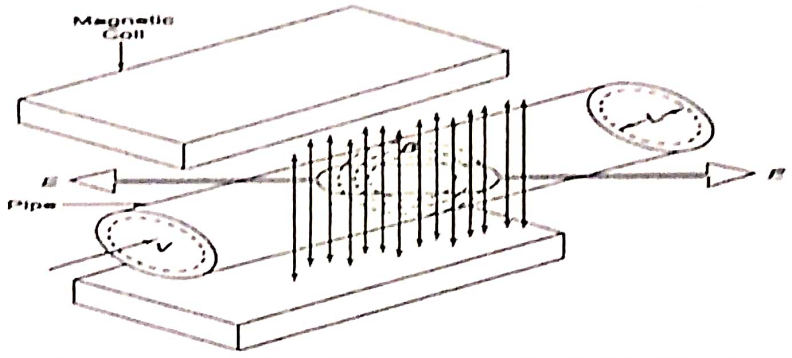


Fig. 13.59 — Working Principle of Magnetic Flowmeter

— 2M

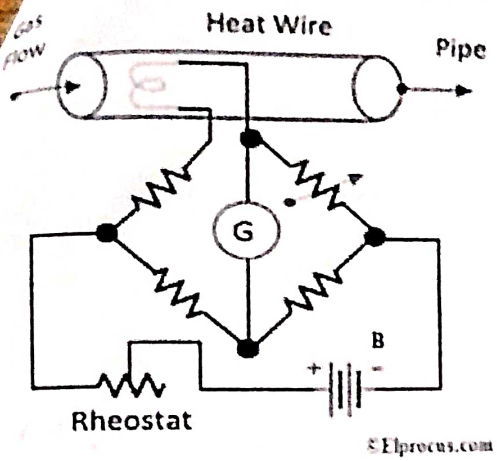
b) With the help of hot wire bridge circuit explain the working of hot wire anemometer in constant current mode and constant temperature mode.

A hot wire anemometer is one kind of instrument, used to measure the direction as well as the velocity of the fluid. So, this measurement can be done by measuring the loss of heat within the wire that is situated in the fluid stream. These devices use a thin wire and it is heated up electrically to some stage of temperature approximately higher than the range of ambient temperature. The **hot wire anemometer basic working principle** is that once an electrically heated up wire is placed within the flow of the gaseous stream, after that the heat gets moved from thin wire to gas so that the wire temperature levels can be reduced. Due to this reason, the resistance value of the wire can also be changed. So this change within wire resistance permits us to measure the liquid flow rate. The hot wire anemometer can be designed with two essential parts namely wheat stone bridge as well as conducting wire. In this construction, a conducting wire is located in the ceramic material. The wires which come from the ceramic material can be connected toward the Wheatstone bridge so that it measures the changes within the resistance value.

Constant Current Method: In the constant current method, the arrangement of a hot wire anemometer can be done within the flow of fluid wherever the flow of liquid speed can be measured. So, a constant magnitude level of current can be supplied from the wire. Also, the wheat stone bridge can be maintained at a fixed voltage level.

Constant Temperature Method: In the constant temperature method, when the electric current supplies through wire then it gets heated. The arrangement of a hot wire anemometer can be done within the flow of fluid wherever the speed of the fluid flow can be measured. Once the wire is arranged within the flow of liquid, and then heat can be transferred toward the fluid from the wire.

— 3M

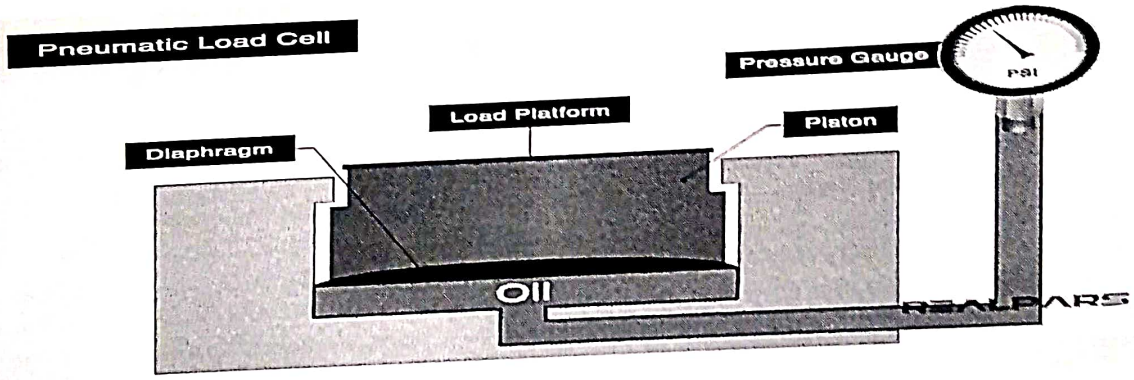


-3M

8. a) How does a pneumatic load cell work? Explain the principle of measuring force using pneumatic load cell?

Principle of Pneumatic Load Cell: If a force is applied to one side of a diaphragm and an air pressure is applied to the other side, some particular value of pressure will be necessary to exactly balance the force. This pressure is proportional to the applied force. Since it is pneumatic, we know that it will deal with air pressure. A pneumatic load cell consists of an elastic diaphragm which is attached to a platform surface where the weight will be measured. There will be an air regulator that will limit the flow of air pressure to the system and a pressure gauge. Thus, when an object is placed on a pneumatic load cell it uses pressurized air or gas to balance out the weight of the object. The air required to balance out the weight will determine how heavy the object weights. The pressure gauge can convert the air pressure reading into an electrical signal.

-3M

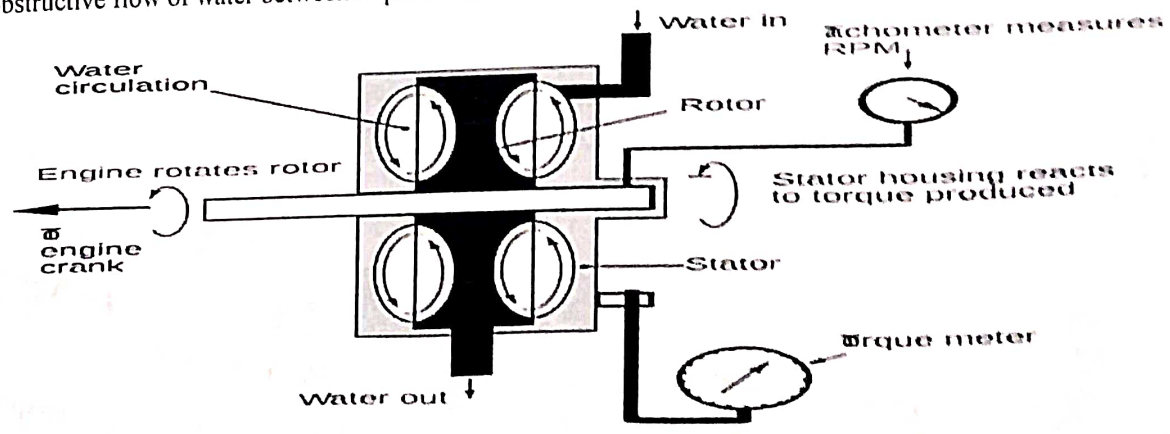


-3M

b) Describe the constructional and operation of hydraulic dynamometer with a neat sketch.

It works on the principle of dissipating the power in fluid friction rather than in dry friction. • It consists of an inner rotating member or impeller coupled to the output shaft of engine, this impeller rotates in a casing filled with fluid. • The heat developed due to dissipation of power is carried away by a continuous supply of working fluid, usually water. • The output can be controlled by regulating the sluice gates which can be moved in and out to partial or wholly obstructive flow of water between impeller and the casing.

-2M



-2M

9. a) Discuss advantages and disadvantages of open loop and closed control systems?

Open Loop System:

Advantages:

1. **Simplicity and stability**: they are simpler in their layout and hence are economical and stable too due to their simplicity.
2. **Construction**: Since these are having a simple layout so are easier to construct.

Disadvantages:

1. **Accuracy and Reliability**: since these systems do not have a feedback mechanism, so they are very inaccurate in terms of result output and hence they are unreliable too.
2. Due to the absence of a feedback mechanism, they are unable to remove the disturbances occurring from external sources.

— 2M

Closed Loop System:

Advantages:

1. **Accuracy**: They are more accurate than open loop system due to their complex construction. They are equally accurate and are not disturbed in the presence of non-linearities.
2. **Noise reduction ability**: Since they are composed of a feedback mechanism, so they clear out the errors between input and output signals, and hence remain unaffected to the external noise sources.

Disadvantages:

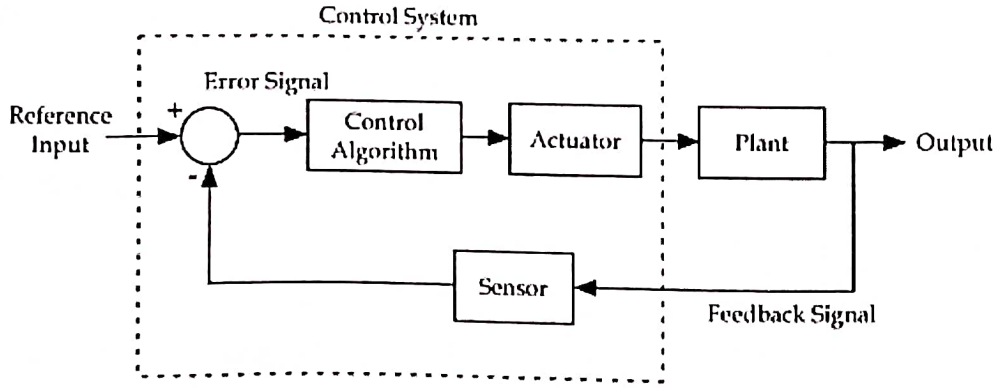
1. **Construction**: They are relatively more complex in construction and hence it adds up to the cost making it costlier than open loop system.
2. Since it consists of feedback loop, it may create oscillatory response of the system and it also reduces the overall gain of the system.
3. **Stability**: It is less stable than open loop system but this disadvantage can be striked off since we can make the sensitivity of the system very small so as to make the system as stable as possible.

— 3M

b) Describe servo mechanism. Draw block diagram of a servo mechanism.

servomechanism, automatic device used to correct the performance of a mechanism by means of an error-sensing feedback. The term servomechanism properly applies only to systems in which the feedback and error-correction signals control mechanical position or one of its derivatives such as velocity or acceleration. Servomechanisms were first used in gunlaying (aiming) and in fire-control and marine-navigation equipment. Today, applications of servomechanisms include their use in automatic machine tools, satellite-tracking antennas, celestial-tracking systems on telescopes, automatic navigation systems, and antiaircraft-gun control systems. All servomechanisms have at least these basic components: a controlled device, a command device, an error detector, an error-signal amplifier, and a device to perform any necessary error corrections (the servomotor). In the controlled device, that which is being regulated is usually position. This device must, therefore, have some means of generating a signal (such as a voltage), called the feedback signal, that represents its current position. This signal is sent to an error-detecting device.

— 1M



— 3M.

01/12/2020

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