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Internal Assessment Test - III

Sub:	Sensors and Transducers							Code:	21EE641
Date:	29-07-2024	Duration:	90 mins	Max Marks:	50	Sem:	6th A&B	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE	
			CO	RBT
1.a	Briefly explain Rotameter.	6	CO6	L2
1.b	An accelerometer has a seismic mass of 0.06 kg and a spring constant of 4500N/m maximum mass displacement is 0.025 m. Determine maximum measurable acceleration and natural frequency.	4	C06	L3
2	What is a Dynamometer? Explain construction and working of the prony brake.	10	CO6	L2
3	Explain i) Ultrasonic Liquid Level Measurement System ii) Humidity Measurement	10	CO6	L2
4	Explain the theory operation of electromagnetic flow meters with suitable diagrams.	10	CO6	L2

CCI **CI** **HOD**

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Internal Assessment Test - II

Sub:	Sensors and Transducers							Code:	21EE641
Date:	29-07-2024	Duration:	90 mins	Max Marks:	50	Sem:	6th A& B	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE	
			CO	RBT
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2	What is a Dynamometer? Explain construction and working of the prony brake.	10	CO6	L2
3	Explain i) Ultrasonic Liquid Level Measurement System ii) Humidity Measurement	10	CO6	L2
4	Explain the theory operation of electromagnetic flow meters with suitable diagrams.	10	CO6	L2

CCI **CI** **HOD**

5.a	A platinum resistance thermometer(RTD) has a resistance of 100 Ω at 25°C. The resistance temperature coefficient of platinum is 0.00392Ω/°C.a. Find its resistance at 50°C b. If the thermometer has a resistance of 200Ω, calculate the value of temperature.	6	CO6	L3
5.b	Explain Hot Wire Anemometer.	4	CO6	L2
6	Briefly explain thermocouples. Also mention the practical use of them.	10	CO6	L2
7	Write a short note on the venturimeter.	10	CO6	L2

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6	Briefly explain thermocouples. Also mention the practical use of them.	10	CO6	L2
7	Write a short note on the venturimeter.	10	CO6	L2

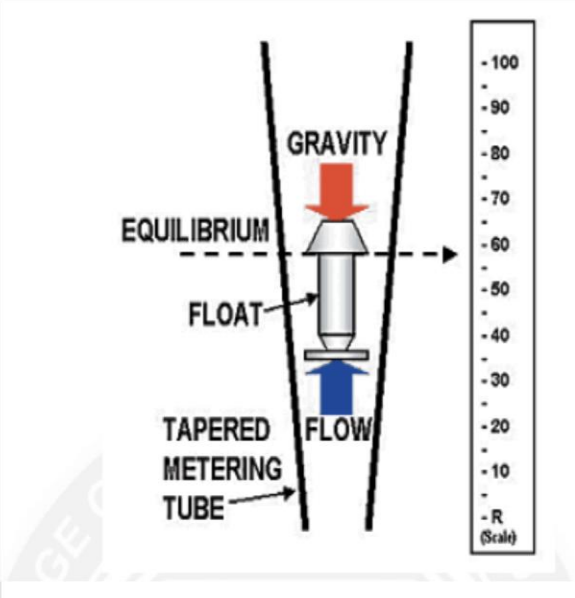
Sensors and Transducers IAT III Qp & Soln

1. a.Briefly explain Rotameter.

Rotameter

Rotameter is a device which is used in chemical and related industries in order to measure the flow rate or average velocity of the flowing fluid.

Rotameter is a simple equipment which consists of a tapered tube and a float. The float is placed inside the tube and usually nets are placed at both the ends of the tube. This arrangement can be connected with a pipe line with flanged connections. Rotameters are always installed vertically in the pipelines. A scale is marked on the tube to read the values of flow rate directly.



When the fluid is not flowing then the float rests at the bottom of the rotameter. The fluid is made to pass through the rotameter such that the direction of flow of the fluid is parallel to the axis of the rotameter.

The flow of fluid through the rotameter causes the float to move along with the fluid. There are two primary forces involved, an upward drag force due to the motion of the fluid in upward direction and a downward force due to gravity which is due to the weight of the float itself. When these forces are balanced then the float moves to a particular location in the tube and it stays right there because it has achieved dynamic equilibrium.

In case it happens that the flow rate of fluid flowing through the rotameter is very high then it may happen that the float may get swept along with the fluid. The nets attached to either side of the rotameter ensure that the float does not get carried away in the pipeline. If it happens then it may get stuck near a valve in pipeline and cause blockage or enter equipment down the line and cause it to malfunction. A down side of net is that if the flow rate of flowing fluid is very high then the float will get stuck near the net and act as a blockage for the fluid flow, this may cause the flanges to get weakened and the liquid may start showering at the site of rupture.

1. b An accelerometer has a seismic mass of 0.06 kg and a spring constant of 4500N/m maximum mass displacement is 0.025 m. Determine maximum measurable acceleration and natural frequency.

Solution: Given: $m = 0.06$ kg; $k = 4500$ N/m and $d = \pm 0.05$ m

We know that the natural frequency,

$$\omega_o = \sqrt{\frac{k}{m}}$$

$$= \sqrt{\frac{4500}{0.06}} = 273.86 \text{ rad/s}$$

We also know that the maximum acceleration,

$$= \omega_o^2 \times d$$

$$= (273.86)^2 \times 0.025 = 1875 \text{ m/s } \textbf{Ans.}$$

and the natural frequency,

$$f_o = \frac{\omega_o}{2\pi}$$

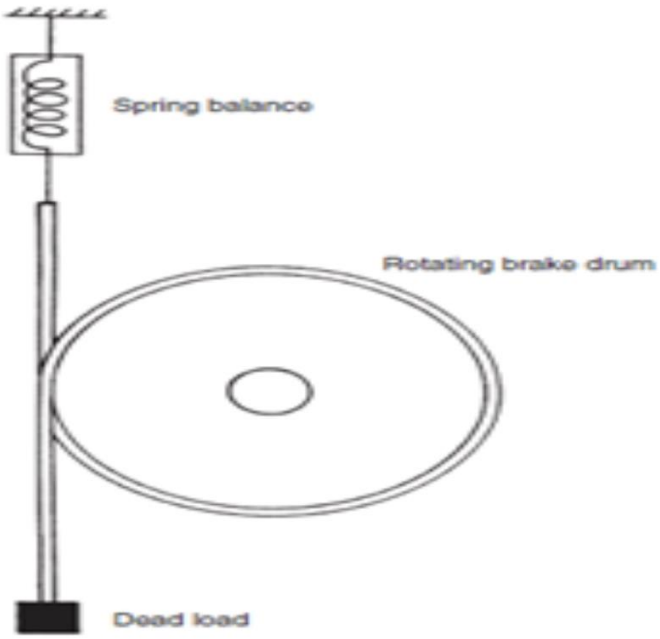
$$= \frac{273.86}{2\pi}$$

$$= 44 \text{ Hz } \textbf{Ans.}$$

2. What is a Dynamometer?Explain construction and working of the prony brake.

Dynamometer is a device used to measure the torque being exerted along a rotating shaft so as to determine the shaft power input or output of power generating, transmitting and absorbing machinery.

Prony Brake



The Prony brake is another torque- measuring system that is now uncommon. It is used to measure the torque in a rotating shaft and consists of a rope wound round the shaft, as illustrated in Figure. One end of the rope is attached to a spring balance and the other end carries a load in the form of a standard mass, m.

If the measured force in the spring balance is Fs, then the effective force, Fe, exerted by the rope on the shaft is given by

$Fe = mg - Fs$

If the radius of the shaft is Rs and that of the rope is Rr, then the effective radius, Re, of the rope and drum with respect to the axis of rotation of the shaft is given by

$Re = Rs + Rr$

The torque in the shaft, T, can then be calculated as

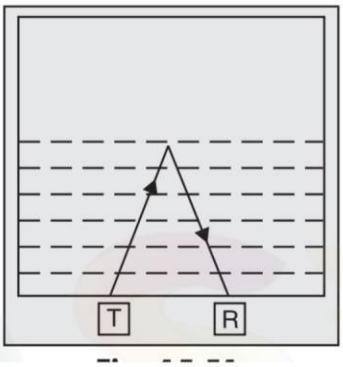
$T = FeRe$

While this is a well-known method of measuring shaft torque, a lot of heat is generated because of friction between the rope and shaft, and water cooling is usually necessary.

3. Explain i) Ultrasonic Liquid Level Measurement System ii) Humidity Measurement

15.36 Ultrasonic Liquid Level Measurement System

Ultrasonic method can be effectively used for measurement of liquid level in a sealed tank. An ultrasonic transmitter and receiver pair is mounted at the bottom of the tank. Ultrasonic wave can pass through the liquid, but gets reflected at the liquid-air interface, as shown in Fig. 15.51. The time taken to receive the pulse is measured, that can be related with the liquid level. For accurate measurement, variation of speed of sound with the liquid density (and temperature) should be properly compensated.



Humidity Measurement

Humidity measurement finds wide applications in different process industries. Moisture in the atmosphere must be controlled below a certain level in many manufacturing processes. Humidity inside an incubator must be controlled at avery precision level.

Textiles, papers and cereals must be dried to a standard storage condition inorder to prevent the quality deterioration.

A hygrometer measures the value of humidity in term of relative humidity.Their dimensions change with humidity.

The humidity can be expressed in different ways: (a) absolute humidity, (b) relative humidity and (c) dew point.

Types of Humidity Measurement

Resistive Hygrometer: The resistive hygrometer based on the property that the resistance of material changes with humidity in presence of hygroscopic materials.

Capacitive Hygrometer:The capacitance of the material changes with changes in dielectric constant of the material between two parallel plates.

Crystal Hygrometer: This method is based on the principle that the humidity change of hygroscopic material is calibrated in terms of the frequency changes of an oscillator.

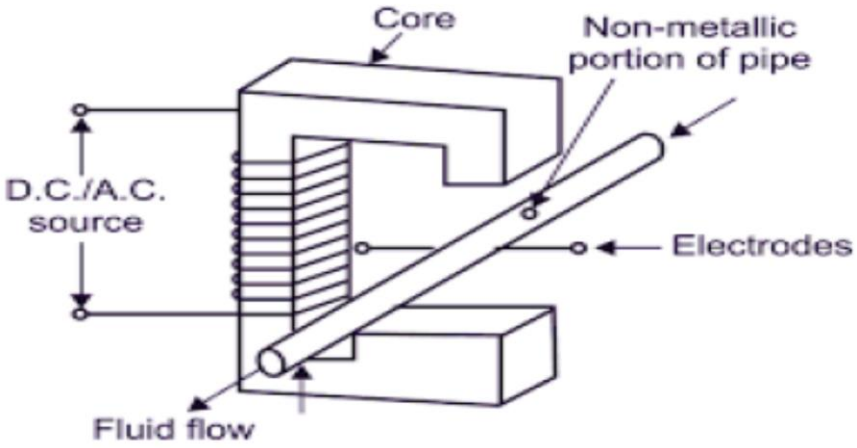
Infrared techniques:

Psychrometer:

Dew point measurement:

4. Explain the theory operation of electromagnetic flow meters with suitable diagrams.

Electromagnetic Flow meters



Principle

Magnetic flow meters works based on Faraday's Law of Electromagnetic Induction. According to this principle, when a conductive medium passes through a magnetic field B, a voltage E is generated which is proportional to the velocity v of the medium, the density of the magnetic field and the length of the conductor.

In a magnetic flow meter, a current is applied to wire coils mounted within or outside the meter body to generate a magnetic field. The liquid flowing through the pipe acts as the conductor and this induces a voltage which is proportional to the average flow velocity.

This voltage is detected by sensing electrodes mounted in the flow meter body and sent to a transmitter which calculates the volumetric flow rate based on the pipe dimensions.

E is proportional to V x B x L

[E is the voltage generated in a conductor, V is the velocity of the conductor, B is the magnetic field strength and L is the length of the conductor].

It is very important that the liquid flow that is to be measured using the magnetic flow meter must be electrically conductive. The Faraday's Law indicates that the signal voltage (E) is dependent on the average liquid velocity (V), the length of the conductor (D) and the magnetic field strength (B). The magnetic field will thus be established in the cross-section of the tube.

5. a.A platinum resistance thermometer(RTD) has a resistance of 100 Ω at 25°C. The resistance temperature coefficient of platinum is 0.00392Ω/°C.a. Find its resistance at 50°C b. If the thermometer has a resistance of 200Ω, calculate the value of temperature.

$$R_{50} = R_0 \left[1 + \alpha (T - T_0)\right]$$

Substitute the given values:

$$R_{50} = 100 \left[1 + 0.00392 \times (50 - 25)\right]$$

Calculate $(50 - 25)$:

$$50 - 25 = 25$$

Then:

$$R_{50} = 100 \left[1 + 0.00392 \times 25\right]$$
$$R_{50} = 100 \left[1 + 0.098\right]$$
$$R_{50} = 100 \times 1.098$$
$$R_{50} = 109.8\,\Omega$$

ii) Calculate the temperature if the resistance is 200Ω

Given:

- $R_T = 200\,\Omega$
- $R_0 = 100\,\Omega$
- $\alpha = 0.00392\ ^\circ\mathrm{C}^{-1}$
- $T_0 = 25\ ^\circ\mathrm{C}$

Rearrange the formula to solve for T:

$$R_T = R_0\left[1 + \alpha(T - T_0)\right]$$

Solve for T:

$$200 = 100\left[1 + 0.00392(T - 25)\right]$$

Divide both sides by 100:

$$2 = 1 + 0.00392(T - 25)$$

Subtract 1 from both sides:

$$1 = 0.00392(T - 25)$$

Divide both sides by 0.00392:

$$\frac{1}{0.00392} = T - 25$$

Calculate $\frac{1}{0.00392}$:

$$\frac{1}{0.00392} \approx 255.102$$

Then:

$$255.102 = T - 25$$

Add 25 to both sides:

$$T = 255.102 + 25$$
$$T = 280.102\ ^\circ\text{C}$$

So, if the resistance is 200 Ω, the temperature is approximately **280.1 °C**.

5. bExplain Hot Wire Anemometer.

Hot Wire Anemometer

Principle

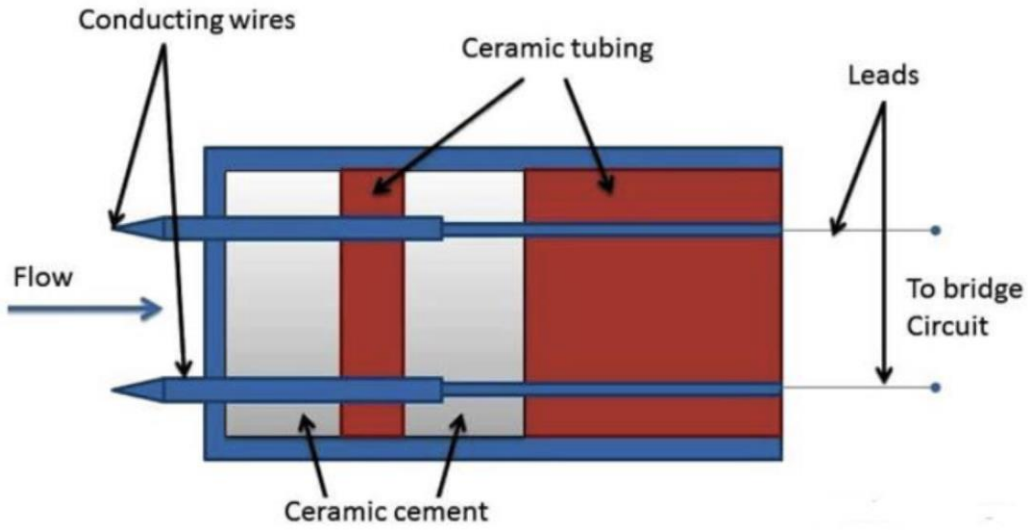
Hot Wire Anemometer works When an electrically heated wire is placed in a flowing gas stream, heat is transferred from the wire to the gas and hence the temperature of the wire reduces, and due to this, the resistance of the wire also changes. This change in resistance of the wire becomes a measure of flow rate.

The main parts of the arrangement are as follows:

• Conducting wires placed in a ceramic body.

• Leads are taken from the conducting wires and they are connected to one of the limbs of the wheatstone bridge to enable the measurement of change in resistance of the wire.

Hot Wire Anemometer



Types of Hot wire Anemometer

There are two methods of measuring flow rate using a anemometer bridge combination namely:

• Constant current method

• Constant temperature method

6. Briefly explain thermocouples. Also mention the practical use of them.

A thermocouple consists of a pair of dissimilar conductors welded or fused together at one end to form the hot or measuring junction with other end available for connection to the cold or reference junction. A thermocouple is a thermoelectric device that converts thermal energy into electrical energy. The thermocouple is used as a primary transducer for measurement of temperature, converting temperature changes directly into emf.

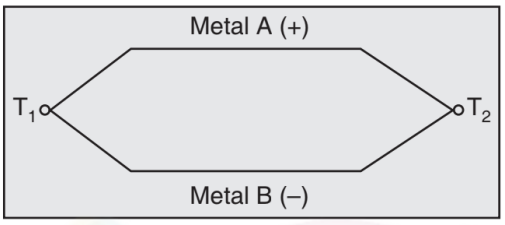


Fig. 15.7.

There are two types of effects that arise when two dissimilar metals are brought in contact with each other and the temperature is changed at the junction. One effect produces an electrical potential (Seeback effect) when heat is applied and the other effect is to cool the junction when a current is passed through the junction in the proper direction (Peltier effect). These two effects can be very useful. Since the voltage at the junction depends upon the temperature of the end points, we may generate a voltage by heating one junction while holding the other constant in temperature. This effect make a cooling device, a refrigerator, by passing a current through the junction in the proper direction.

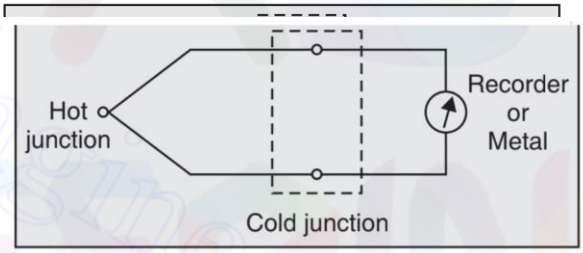


Fig. 15.8.

There are two junctions T_1 and T_2. The junction T_2 is kept at constant reference temperature and referred as cold junction while the junction T_1 is referred as hot junction. When the hot junction temperature is greater as compared to the cold junction an emf is generated due to the temperature gradient. The magnitude of the emf depends on the material used for the wires and temperature difference between the two junctions. A meter or recorder is used to measures emf as shown in Fig. 15.8.

1. The thermocouple junction may be grounded and brought into direct contact with the material being measured.
2. The thermocouples is rugged in construction
3. It cover a wide range of temperature form –270° C to 2700° C.
4. Using extension leads and compensating cables, long distances transmission for temperature measurement is possible.

7. Write a short note on the venturimeter.

Venturimeter

The venturimeter works on the principle of Bernoulli's equation, i.e., the pressure decreases as the velocity increases.

The cross-section of the throat is less than the cross-section of the inlet pipe.

As the cross-section from the inlet pipe to the throat decreases, the velocity of the fluid increases, and hence the pressure decreases.

Due to the decrease in pressure, a pressure difference is created between the inlet pipe and the venturimeter throat.

This pressure difference can be measured by applying a differential manometer between the inlet section and throat section or using two gauges on the inlet section and throat.

The pressure difference through the pipe is calculated after obtaining the flow rate.

Venturimeter Construction

It consists of three parts, the part of the larynx and the deviation. These three parts are arranged in a systematic order. The first is an inlet section or converging section.

This is the area where the cross-section emerges in a conical shape for contact with the throat region. In this section, the cross-section area decreases from beginning to end.

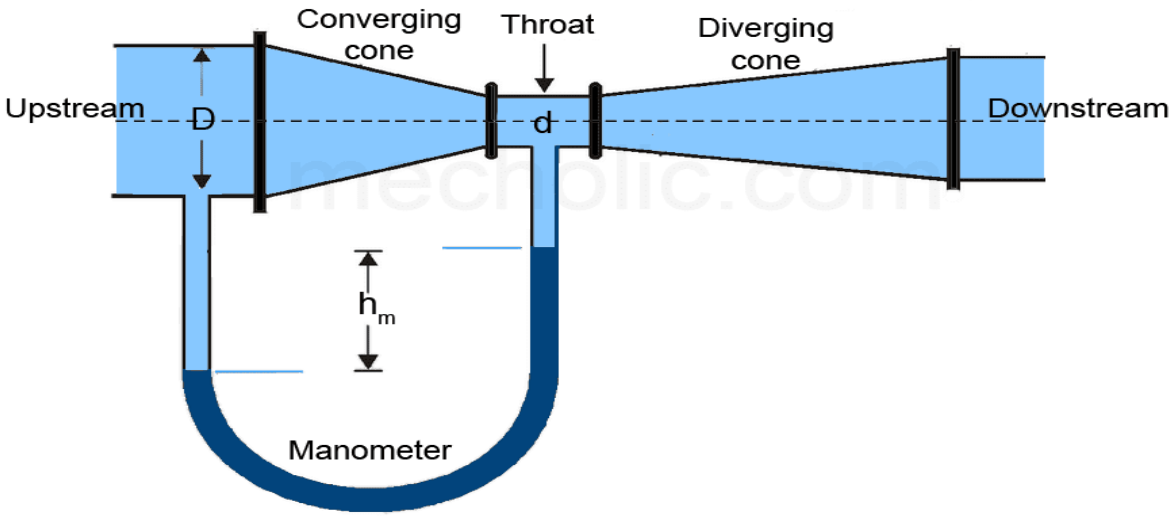
This section is connected by an inlet pipe at one end and a cylindrical throat at the other end. The angle of convergence is typically 20–22 °. the other is a cylindrical larynx.
This is the central part of the venturimeter. It is a cylindrical pipe in the ventimeter through which the fluid passes after converting to the convergence section.

The throat usually has a diameter of the throat that is half the diameter of the pipe. The throat diameter remains the same through its length. The last one is turning the section.

This is the end of the venturimeter. On one side, it is connected to the throat of the venturimeter, and on the other side is attached to the pipe.

Flow rate, Q = Cd. a1. a2 $\sqrt{2gx}$ / $\sqrt{a12-a02}$

The divergent section has an angle of 5 to 15 degrees. The deviation angle is less than the convergence angle because the length of the deviation cone is larger than the convergence cone. The main reason for the small deviation angle is to avoid isolation of the flow from the walls.


Converging cone
Throat
Diverging cone
Upstream
D
d
Downstream
h_m
Manometer