5 psi, what force is exerted on the diaphragm?

5.33 Figure 5.46 shows a proposed sensor for measuring the speed of liquid flowing in an open channel. A SS pressure sensor is connected to a funnel as shown. A pressure is formed when the funnel has its open end pointed upstream so that the liquid is brought to rest against the funnel

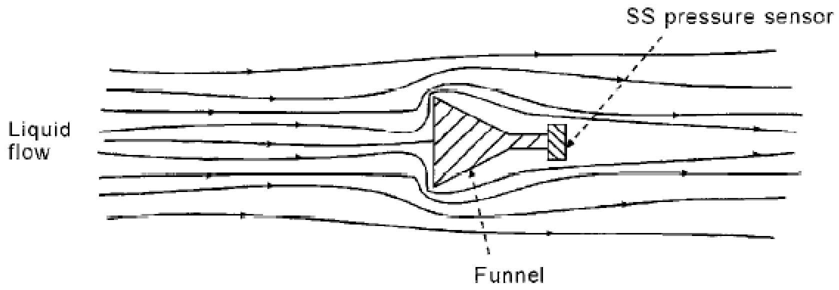


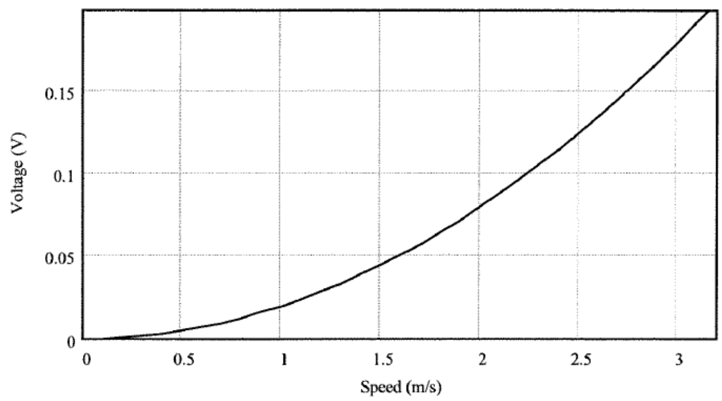
FIGURE 5.46
Figure for Problem 5.33.

opening. The pressure is given by $p = \frac{1}{2}\rho v^2$, where ρ is the liquid density in kg/m^3 and v is the liquid speed in m/s. The SS pressure sensor has a range of 0 to 5 kPa with a transfer function of 40 mV/kPa. Suppose the liquid is water with a density of 1 g/cm^3. What is the maximum speed which can be measured? Plot a graph of sensor output voltage versus liquid speed. Comment on linearity.

5.35
We find the maximum speed by the speed which creates a pressure of 5 kPa. To be consistent with units we find the density in kg/m^3, 1 gm/cm^3 = 1 10^{-3}kg/10^{-6} m^3 = 10^3 kg/m^3. Now for the speed,

$$v_{max} = (2p/\rho)^{1/2} = [2(5 \times 10^3 \text{ Pa})/(10^3 \text{ kg/m}^3)]^{1/2} = 3.16 \text{ m/s (about 7 mph)}$$

The output voltage is given by $V = (40 \text{ mV/kPa})p = (1/2)(40 \times 10^{-6})(10^3 \text{ kg/m3})v^2$. This simplifies to $V = 0.02v^2$. The following graph shows the expected non-linearity because the pressure is related to the square of the speed.



5.12 A strain gauge has GF = 2.06 and R = 120 Ω, and is made from wire with α_0 = 0.0034/°C at 25°C. The dissipation factor is given as P_D = 25 mW/°C. What is the maximum current that can be placed through the SG to keep self-heating errors below 1 μ of strain?

5.13 A strain gauge has GF = 2.14 and a nominal resistance of 120 Ω. Calculate the resistance change resulting from a strain of 144 μin/in.

5.13

The gage factor is given by $GF = (\Delta R/R) / (\Delta l/l)$ so,

$$\Delta R = GF(\Delta l/l)R$$
$$\Delta R = 2.14(144 \times 10^{-6})(120\ \Omega)$$
$$\Delta R = 0.037\ \Omega$$

An LVDT has a maximum core motion of ± 1.5 cm with a linearity of $\pm 0.3\%$ over that range. The transfer function is 23.8 mV/mm. If used to track work-piece motion from -1.2 to $+1.4$ cm, what is the expected output voltage? What is the error in position determination due to nonlinearity?

Solution

Using the known transfer function, the output voltages can easily be found, $V(-1.2\text{ cm}) =$ (23.8 mV/mm) (-12 mm) $= -285.6$ mV and $V(1.4\text{ cm}) =$ (23.8 mV/mm) (14 mm) $= 333$ mV. The linearity deviation shows up in deviations of the transfer function. Thus, the transfer function has an uncertainty of (± 0.003) (23.8 mV/mm) $= \pm 0.0714$ mV/mm. This means that a measured voltage, V_m (in mV), could be interpreted as a displacement that ranges from $V_m/23.73$ to $V_m/23.87$ mm, which is approximately $\pm 0.3\%$, as expected.

EXAMPLE 5.4 The level of ethyl alcohol is to be measured from 0 to 5 m using a capacitive system such as that shown in Figure 5.10b. The following specifications define the system:

for ethyl alcohol: $K = 26$ (for air, $K = 1$)
cylinder separation: $d = 0.5$ cm
plate area: $A = \pi RL$

where $R = 5.75$ cm = average radius
L = distance along cylinder axis

Find the range of capacity variation as the alcohol level varies from 0 to 5 m.

Solution

We saw earlier that the capacity is given by $C = K\epsilon_0(A/d)$. Therefore, all we need to do is find the capacity for the entire cylinder with *no* alcohol and then multiply that by 26.

$$A = 2\pi RL = 2\pi(0.0575\text{ m})(5\text{ m}) = 1.806\text{ m}^2$$

Thus, for air

$$C = (1)(8.85\text{ pF/M})(1.806\text{ m}^2/0.005\text{ m})$$
$$C = 3196\text{ pF} \approx 0.0032\ \mu\text{F}$$

With the ethyl alcohol, the capacity becomes

$$C = 26(0.0032\ \mu\text{F})$$
$$C = \mathbf{0.0832\ \mu F}$$

The range is 0.0032 to 0.0832 μF.

A strain gauge with GF = 2.03 and R = 350 Ω is used in the bridge of Figure 5.16a. The bridge resistors are $R_1 = R_2$ = 350 Ω, and the dummy gauge has R = 350 Ω. If a strain of

1450 μm/m is applied, find the bridge offset voltage if V_s = 10.0 V. Find the relation between bridge off-null voltage and strain. How much voltage results from a strain of 1 micro?

Solution

With no strain, the bridge is balanced. When the strain is applied, the gauge resistance will change by a value given by

$$\mathrm{GF} = \frac{\Delta R/R}{\text{strain}}$$

Thus,

$$\Delta R = (\mathrm{GF})(\text{strain})(R)$$
$$\Delta R = (2.03)(1.45 \times 10^{-3})(350\ \Omega)$$
$$\Delta R = 1.03\ \Omega$$

Thus, the new resistance R = 351 Ω. The bridge offset voltage is

$$\Delta V = \frac{RV}{R_1 + R} - \frac{R_A V}{R_A + R_2}$$

Thus,

$$\Delta V = 5 - \frac{(351)(10)}{701}$$
$$\Delta V = \mathbf{-0.007\ V}$$

so that a 7-mV offset results.

The sensitivity is found from Equation (5.14):

$$\Delta V = -\frac{10}{2}(2.03)\frac{\Delta l}{l} = -10.15\frac{\Delta l}{l}$$

Thus, every micro of strain will supply only 10.15 μV.

A U tube manometer employs olive oil having a specific gravity of 0.82 as the manometer liquid. One limb of the manometer is exposed to the atmosphere at a pressure of 740 mm Hg and the difference in column heights is measured as 20 cm when exposed to an air source at 25°C. Calculate the air pressure in Pa.

Given: 1 atm = 101 325 Pa.

Density of water at 25°C=996kg/m^3

Density of air at =1.15 kg/m^3

The level of ethyl alcohol is to be measured from 0 to 5 m using a capacitive system such as that shown in Figure 5.10b. The following specifications define the system:

$$\text{for ethyl alcohol: } K = 26 \text{ (for air, } K = 1)$$
$$\text{cylinder separation: } d = 0.5 \text{ cm}$$
$$\text{plate area: } A = \pi RL$$

where $R = 5.75$ cm = average radius
L = distance along cylinder axis

Find the range of capacity variation as the alcohol level varies from 0 to 5 m.

Solution

We saw earlier that the capacity is given by $C = K\epsilon_0(A/d)$. Therefore, all we need to do is find the capacity for the entire cylinder with *no* alcohol and then multiply that by 26.

$$A = 2\pi RL = 2\pi(0.0575 \text{ m})(5 \text{ m}) = 1.806 \text{ m}^2$$

Thus, for air

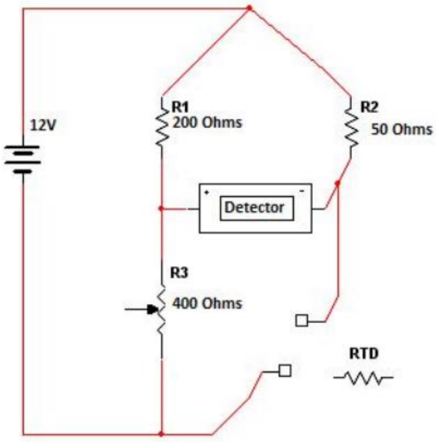
$$C = (1)(8.85 \text{ pF/M})(1.806 \text{ m}^2/0.005 \text{ m})$$
$$C = 3196 \text{ pF} \approx 0.0032\ \mu\text{F}$$

With the ethyl alcohol, the capacity becomes

$$C = 26(0.0032\ \mu\text{F})$$
$$C = \mathbf{0.0832}\ \boldsymbol{\mu F}$$

The range is 0.0032 to 0.0832 μF.

A platinum RTD is used for measuring the temperature of a cooling bath. The RTD is connected in a bridge circuit as shown in the Fig(i).The bridge is balanced when the temperature of the bath is 0^oC.Find out the temperature of the cooling bath when the balance detector reads a voltage of 3V. Assume the RTD follows a linear temperature resistance characteristics.Temperature coefficient of resistance of Platinum =$0.00385/^oC$



A sensing system must be designed to measure and monitor the temperature at six points of a furnace.

The range of the temperature at the six points and the accuracies of the measurement required as follows:

2 interior points (A and B): 600-1100°C accuracy of +/- 5°C
1 interior point (C):1000-1500oC, accuracy of +/- 50°C
1 outside point(D): 40-100°C, +/- 0.5°C
2 outside points (E and F): 15-40°C, +/- 0.1°C.

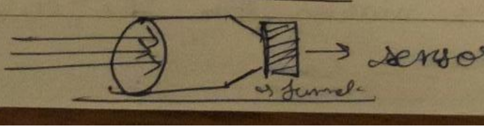
Choose corresponding sensors for this system and brief about how these can be connected for an efficient monitoring system.

$e \rightarrow$

X ——————— X ——————— X

13/05/22

Q A pressure is ~~deployed~~ to measure the velocity of a fluid flowing through a tube in such a way that a pressure is formed when the fluid get stopped when it passes through a funnel at the end of which a sensor is placed as shown in the figure. Pressure velocity characteristic is calibrated to be $P = \frac{1}{2}\rho v^2$. Sensor has a range of 0–5 kPa w/ sensitivity of 40 mV/kPa

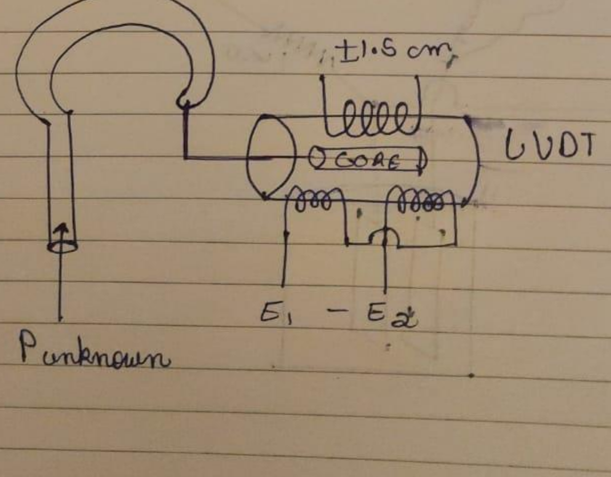


what is the max speed of water the sensor can measure

& find the eq^n of $\vec{v}$ v/s o/p voltage

~~Sol~~ Q2 A strain gauge has gauge factor GF = 2.14 & a nominal resistance of 120 Ω. Calculate the resistance change resulting from a strain of 144 μ inch/inch. ($\Delta L/L$)

Q3 An LVDT is used for the measurement of pressure using a Bourdon tube as shown in the figure. It has a max core motion of ± 1.5 cm w/ a linearity of ± 0.3% over the range. The transfer f^n = 23.8 mV/mm. Pressure is measured from a minimum to a max. value when LVDT core displaces from −1.2 to + 1.4 cm. What would be the expected o/p voltage & what is the error in pressure measurement due to non linearity



(2) Pt RTD used for measuring temp. of cooling bath. RTD is connected in a wheatstone bridge. The bridge is balanced at 0°C bath temp. Find out the temp of the bath if the o/p voltage of the bridge is 8V. Assume the RTD follows a linear temp resistance characteristic. α of Pt = ~~0.003~~
= 0.00385/°C

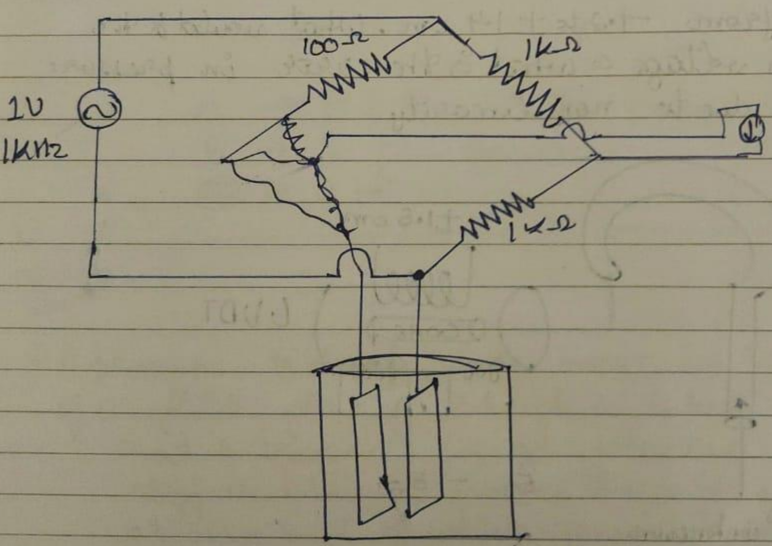
[illegible]

Q4 The level of ethyl alcohol is to be measured by a capacitive transducer from 0 to 5 metres as shown. Specs. given are:

$$\varepsilon_{C_2H_5OH} = 26 \quad , \quad \varepsilon_{air} = 1 \quad , \quad d = 0.5\,cm$$

$$A = 1.806\ m^2$$

If the sensor is used ~~for the~~ in a wheatstone bridge for the conversion of level to a corresponding voltage as shown, find out the o/p range if level varies from 0 to 5 m
$\nu = 1kHz$



* 8. A sensing system has to be designed to measure & monitor the temp. at 6points of a furnace. The range of temp. at the 6 points required are ~~at~~ as follows:

2 interior points	A & B	:	600 - 1100°C
	C	:	1k - 1500 °C
	D	:	40 - 100 °C
	E & F	:	15 - 40 °C

Choose corresponding sensors for this system with suitable signal conditioning circuits to give the o/ps in voltage.

* A platinum RTD is used for measuring the temp. of a cooling bath. The RTD is connected in a Wheatstone Bridge circuit. The bridge is balanced when the temp of the bath is 0°C. Find out the temp of the bath if the o/p voltage of the bridge is -3V. Assume the RTD as follows:
A linear temp resistance characteristics, temp. coefficient of platinum is 0.00385/°C