Measurement and Instrumentation Laboratory (EE3P005)

EXPERIMENT-2

Strain Gauge Experiment

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AIM OF THE EXPERIMENT:

Measuring strain using strain gauge transducer and measuring corresponding voltage developed.

APPARATUS REQUIRED:

- Stainless Steel Strip
- Strain Gauge foil
- Built in power supply
- 3 ½ digital supply
- Different Weights, weighing upto 1kg supplied
- Strain Gauge Transducer Assembly
- Measuring Instrument

THEORY:

Strain Gauge Transducer: Strain Gauge is a passive transducer. This is used to measure the lateral strain exerted on a given surface. This sensor converts a mechanical displacement into a change in resistance. Positioning and quality of bonding the sensor on the surface, largely determines the accuracy. An optional external Wheatstone's bridge is used to measure bridge imbalance, which is a measure of strain. A bridge is symmetrical, four-element, circuit that enhances the instrument's ability to detect small changes in the sensor. Four Strain gauge sensors arranged in the bridge configuration, balances out fixed or quiescent voltage drop, allowing magnification of the different signal. This acquired signal is conditioned and computed to indicate actual strain suffered by the surface.

Strain Measurement: Strain may be sensed either directly or indirectly. Electrical resistance strain gauges are inherently sensitive to strain; that is their unit resistance changes directly proportional to their unit dimensional change. However, until about 1930 the common experimental procedure consists of measuring the strain displacement 'L' over some initial gauge length 'l' and then calculating the resulting average strain using formula E1= 9/G

Electrical Strain Gauges: The development of strain gauges as followed many different approaches and gauges have been based on mechanical optical, electrical, and pneumatic principles, when electrical strain gauges were first introduced the gauges element was produced by winding grid with very fine diameter wire. Standard gauge resistance is 120 ohms and 350 ohms. But in some configurations resistance of 600 ohms and 1000 ohms are available. The gauges are normally fabricated by advance isoelastic alloys.

The Whetstone Bridge for Strain Gauge Signal Conditioning: Since the Whetstone Bridge is the most commonly employee circuit to convert the resistance changes R/R from a strain gage to an output voltage E; its application for this purpose is considered in details in this section. One of the first questions that arises pertaining to use of the whetstone bridge for strain measurements concerns location of the gage or gages within the bridge.

Cantilever Beam Setup: A simple cantilever beam with two-strain gage on the top surface and two strains gage on the bottom surface serves as the elastic member. The gages are wired into a whetstone bridge as shown in the figure. The load applied at the end of the beam produces a movement M=Px at the gage location x that results in the following strains so

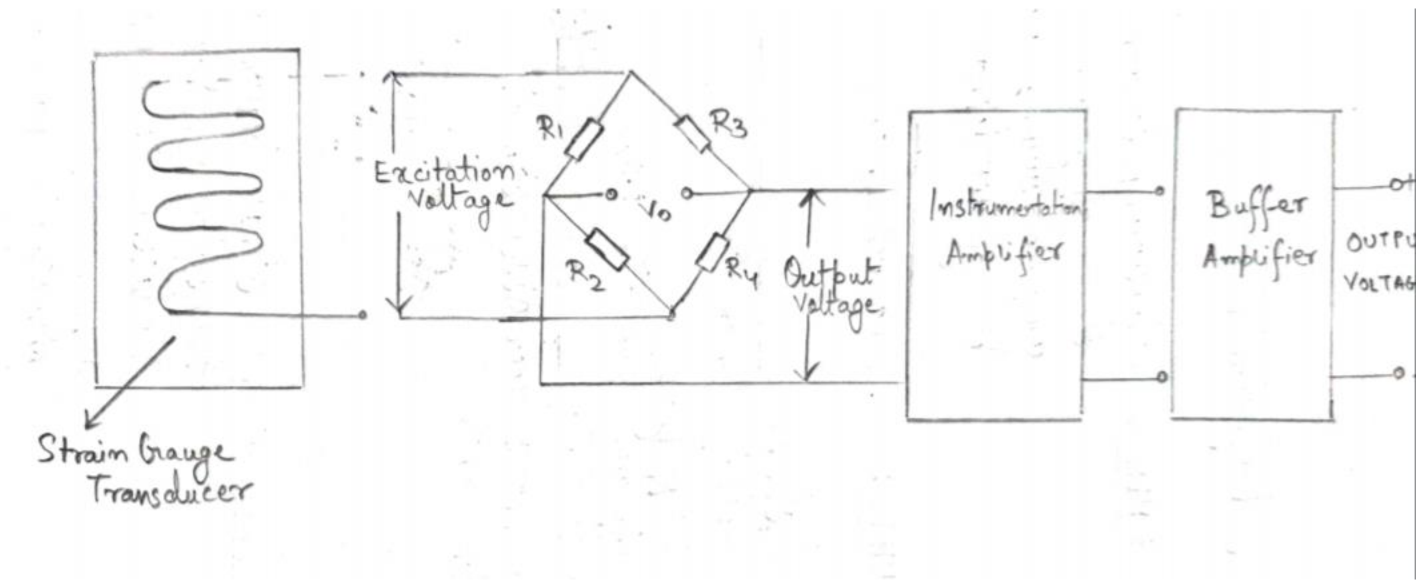
$$\Sigma = \frac{6M}{Ebh2} = \frac{6Px}{Ebh2}$$

Where b is the width of the cross section of the beam
Where h is the height of the cross section of the beam

So the response of the strain gages is obtained from the equation

$$\frac{\Delta R}{R} = \frac{6sg \times Px}{Ebh2}$$

CIRCUIT DIAGRAM:



PROCEDURE:

Initial Calibration Procedure to measure strain:-

This is already calibrated at the factory.

1. Connect the strain interfacing module to 230 V.A.C. supply
2. Do not add weights on the weighing pan. Let it be freely suspended. The pan tends to move or oscillate like a pendulum. Use your hand and prevent this oscillation. This is to ensure the calibration is good.
3. Use the multimeter to measure the output voltage or read on DPM. There are two terminals on the right hand side of the measuring instrument. These are output terminals. You have to measure the voltage at these terminals. Set the meter in DC-Volt 2V range. Built-in DPM will display the same as multimeter.
4. Now measure the output voltage. It must be equal to 0 volts.
5. Otherwise adjust the ZERO potentiometer on the measuring instrument.
6. Now add 1-kg weight gently in the suspended pan.
7. Measure the output voltage it must be equal to 317mV corresponds to 1000 gms. This is a direct reading or indication of strain suffered by the transducer. But the DPM reads 317μ Strain. This is the actual strain suffered by the strain gauges.
8. Otherwise adjust the SPAN potentiometer in the measuring instrument to set 317mV on the Multimeter.
9. Repeat Step No: 2 through 6 four or five times, till the readings are repeatable.
10. Now the system is calibrated. Hence there is no need to adjust the potentiometers further. And the system is ready for operation.

Experiment Procedure:-

1. Verify the system is calibrated.
3. Add 100 gms of weights and measure the output voltage using Multimeter or Note down strain on DPM readings and tabulate.
4. Increase the weight to 150 gms and measure the output voltage, and record.
5. Similarly increase the weight up to 1000 gms in steps of 50 gms and tabulate the readings as shown.

OBSERVATION:

Weight (In Kg)	Calculated Strain (Y) in μ Strain	$V_1 - V_2$ (mV)	$\Delta V = (V_1-V_2)_{Load} - (V_1-V_2)_{no\ Load}$	Calculated Strain using V_1-V_2 in μ strain	Strain output in μ strain	O/P Voltage (mV)
0.200	63.12	3.2	1.2	66.66	64	65
0.5	157.80	5.0	3	166.66	160	161.6
1	315.62	8.0	6	333.33	318	~~318~~ 318

Calculations:

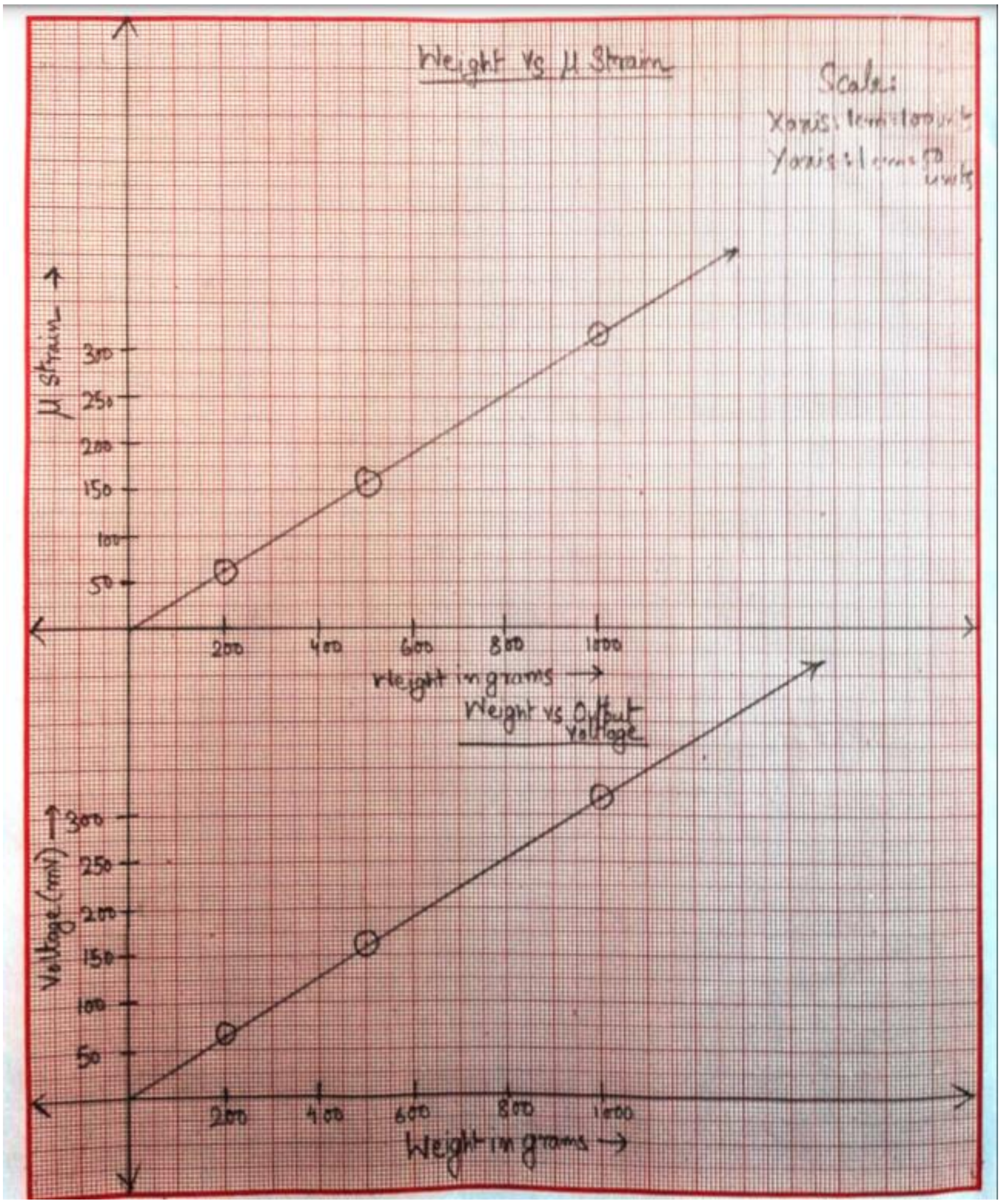
Strain calculation by Young Modulus $= \dfrac{6mgL}{YBT^2}$

200 gm, Strain Cal $= \dfrac{6 \times 0.2 \times 9.8 \times 0.25}{2.07 \times 10^{11} \times 0.025 \times 0.7^2 \times 10^{-4}} = 63.12\ \mu$ strain

500 gm, Strain Cal $= \dfrac{6 \times 0.5 \times 9.8 \times 0.25}{2.07 \times 10^{11} \times 0.025 \times 0.3^2 \times 10^{-4}} = 157.80\ \mu$ Strain

1 Kg, Strain Cal $= 315.62\ \mu$ Strain.

Graph:



CONCLUSIONS:

We conclude from this experiment that application of stress on the load cell result to a decrease in output voltage. Also we saw both the graphs of weight vs o/p voltage ad weight vs µ strain which were both straight lines.

DISCUSSION

1. What is the function of the Zero Adjustment and how do you think it is done here?

The function of the zero adjustment is to make the pan weight and suspended bar weight to zero so that when weight is applied the readings won't be affected and readings will be due to the weight applied.

Here, the pan is kept empty and the reading is adjusted to zero using zero adjustment.

2. List some properties for the material to be used for Strain Gauge?

The material used in making wire in the strain gauge should have less thermal coefficient so that resistance change due to temperature is less.

3. What is Gauge Factor (definition and unit only)?

Gauge factor (GF) is the ratio of relative change in electrical resistance R, to the mechanical strain ε.

$$GF = \frac{\Delta R/R}{\Delta L/L} = \frac{\Delta R/R}{\varepsilon}$$

Although it is dimensionless, it is measured in **microstrain** (**με**)