Unit - IV

Stress strain measurements

Types of strain gauges

→ photo elasticity

→ Brittle lacquer gauges

→ strain gauges

- Non electrical [static] loads
  - mechanical
  - optical
  - photo elasticity
- electrical [Dynamic] loads
  - resistence type
  - capacitance | Inductance

used for large mass & size

retained for long period of time

Requirements of strain gauges :-

→ Small size and negligible mass

→ simple and easy to attachment to the specimen under test

principle :-

→ It is based on when a conductor is subjected to mechanical deformation its length and diameter are change, also change in its resistence

W.K.T $R = \frac{\rho l}{A}$

Here ρ - specific resistance

L - length

A - Area

apply 'log' on both sides

$$\log R = \log \rho + \log l - \log A$$

$$\frac{dR}{R} = \frac{d\rho}{\rho} + \frac{dl}{l} - \frac{dA}{A}$$

$$\text{Area } A = \frac{\pi}{4} d^2 = cd^2$$

$$A = cD^2$$

$$\frac{dA}{A} = \frac{2c\,dD}{D}$$

$$\frac{dR}{R} = \frac{d\rho}{\rho} + \frac{dl}{l} - \frac{2c\,dD}{D}$$

$$\frac{(dR/R)}{(dl/l)} = \frac{(d\rho/\rho)}{(dl/l)} + 1 - \left[\frac{2c\,dD}{D}\right]\frac{dl}{l}$$

$$F = \frac{(dR/R)}{(dl/l)} = \text{gauge factor}$$

$$F = \frac{(d\rho/\rho)}{(dl/l)} + 1 - 2\mu$$

$$\mu = \left[\left[\frac{c\,dD}{D}\right]\left(\frac{dl}{l}\right)\right]$$

Metal Resistence strain gauges :-

(i) un bounded strain gauges

(ii) bounded strain gauges

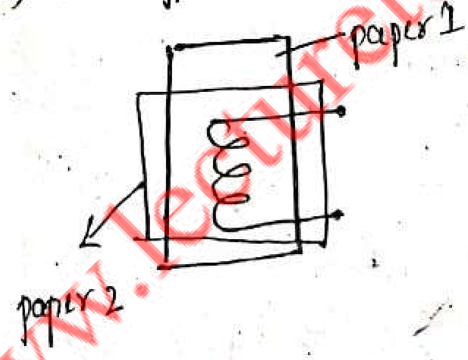
(i) un bounded strain gauges :- (change in length)

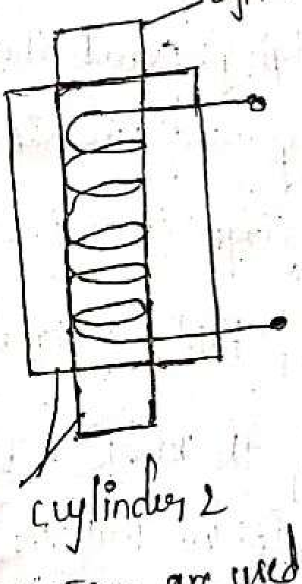
the resistence wire are streached around rigid and electrically insulated fins on two frames A & B which can relatively moved. each other the strain can be detected through change in resistence of wire in electrical circuit the wire and pins are not permanently fitted, simply by screwed.

→ unbounded gauges are specially used for pressure, force

(ii) Bounded strain gauges [change in dia] :-

(a) Wire type strain gauges :-





A ~~wire~~ very fine wire of diameter 0.025mm are used in the form of grid shape consists of a series of a long parallel loops with leads.

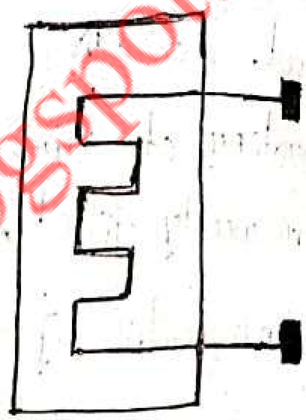
→ leads and connections terminals provided for the above loops for satisfying performance the bond b/w the resistance elements and cement joints are arranged.

→ Along with grid wire backlite (or) paper used as a cover plates.

(b) metal foil type gauges :-

→ the gauge is provided by a printed circuit board with design grid shapes.

→ the Designed grid pattern is first provided on the Thin sheet of metal alloy with acid resistance link, chemical

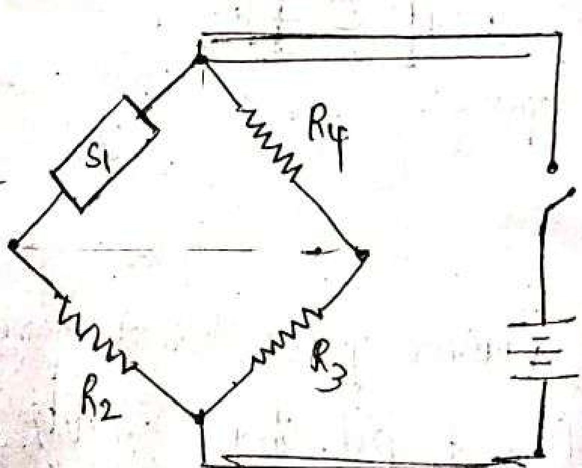


These can be successfully employed to fill & shaping of the metal foil.

the satisfying curved shapes are achevied due to chemical machining and accurate construction.

Strain gauge circuits :-

(i) quarter bridge gauges :-

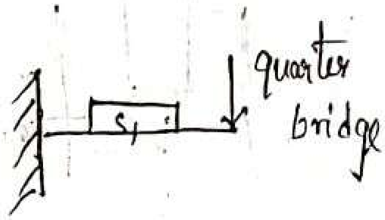


→ Intially the bridge resistence are so adjusted That The bridge is balanced

→ After gauges are strained the equilibrium gets distrubed.

→ Here R_1 is strain gauge is under Tension load and R_2, R_3, R_4 are fixed resistors when gauge is strained the change in voltage in the circuit is

$$dv_0 = \frac{v_s}{4}\left(\frac{dR}{R}\right)$$

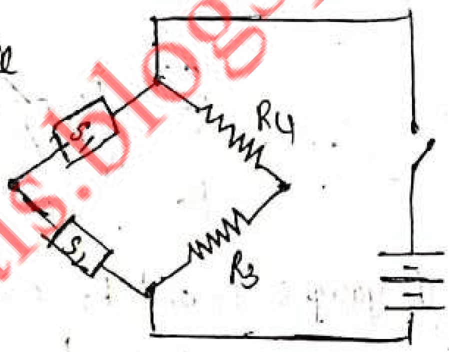


v_s – starting voltage

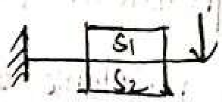
(ii) Half Bridge gauge :-

→ Two of the bridge elements are strain gauges and other two are fixed resistors

→ the gauge 'S_1' surface is upper surface of cantilever beam, the gauge 'S_2' bounded to lower surface of beam



$$dv_0 = \frac{V_s}{2}\left(\frac{dR}{R}\right)$$



Rosettes of strain [strain Rosettes]:-

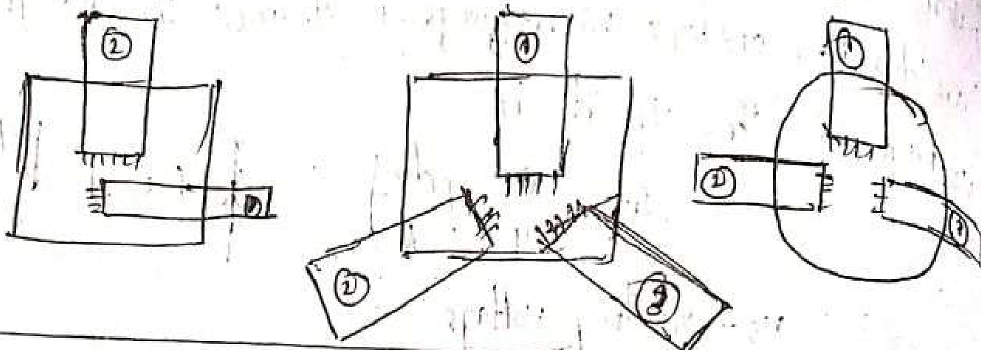
→ single gauges are used for uniaxial loads that is when a member loaded either in Tension (or) compression

→ For biaxial stress feeds two (or) more gauges used in different directions.

→ A group of gauges bounded to same supporting material in different relative positions depending upon arrangement rosettes (or) gauge of gride those names as multi gride

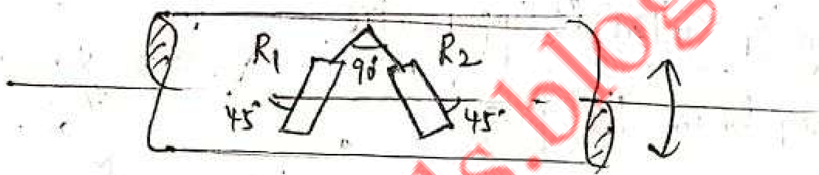
rosettes

Ex: Rectangular, Delta, T-delta rosette.



strain gauges are used for Torsion :-

→ when a bar subjected to pure tension the maxi. Tensile and Compressive strains occurs at 45° to axis of the bar



→ the gauges R_1 and R_2 are located along the principle direction the gauges are at 90° to each other

→ Here the resistence of strain gauges R_1 increases due to Tensile strain the resistence of strain gauge R_2 decreases due to Compressive strain

→ These strain gauges are connected electrically in adjustment sides of half bridge circuit

→ the strain sensed by each gauge will be

strain in gauge $R_1 = \epsilon_d + \epsilon_s + \epsilon_e$

" " " $R_2 = \epsilon_d - \epsilon_s + \epsilon_e$

change in output voltage

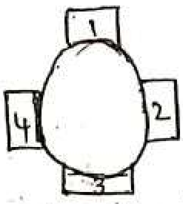
$$dv_0 = \frac{V_s}{4}\left[\frac{dR_d}{R_1} + \frac{dR_s}{R_1} + \frac{dR_e}{R_1}\right] - \left[\frac{dR_R}{R_2} - \frac{dR_s}{R_2} + \frac{dR_e}{R_2}\right.$$

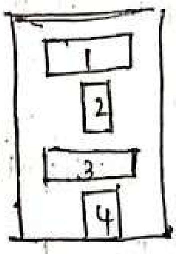
$$dv_0 = \frac{V_s}{4}\left[-\frac{dR_1}{R}\right]$$

if $R_1 = R_2 \Rightarrow dv_0 = \frac{V_s}{4}\left[\frac{dR_s}{R}\right]$

Arrangement for axial Thrust:-

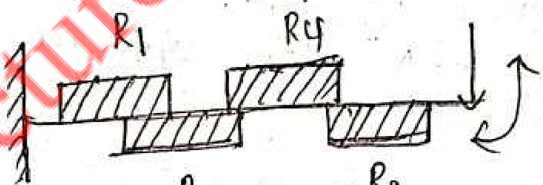
→ circular bar subjected to axil thrust and bearing moment





→ The measurement of strem under Conditions of axial loading by mounting four gauges on Test specimen two gauges R_1, R_3 are placed axially and other two gauges R_2, R_4 are placed circumferentially These effect eliminate bending effects.

→ For measurement of bending moment two gauges R_1, R_4 are mounted on top of the Cantilever specimen R_2, R_3 are the bottom of the Cantilever Specimen



→ The measure of stress under bending moment is acheived by two gauges R_1, R_4 are placed at the top of the test specimen another two gauges R_2, R_3 are Placed at The bottom of the test specimen.

Strain gauge alloys and materials:-

→ The selection of materials used for strain gauges is based on the following parameters

1. High gauge factor
2. resistence change is simple and it is a function of mechanical gauge
3. It is low Temp sensitivity
4. min. Thermo electric tendency at connections
5. High yield point and endurance limit
6. Good work ability and yield ability
7. economical cost

material name:- advance Cu - 57%, Ni - 43%

iridium - platinum - Ir - 5%, Pt - 95%

Iso electric - 36% Ni, 52% fe, 8% - chromium

magnesium - Ni - 4%, 84% - Cu.