ME 120 Experimental Methods

**Force, Torque, Stress, and Strain Measurement**

BJ Furman
25APR06

Strain Gages

- Force, torque, pressure, stress, and strain

\[ R = \frac{\rho L}{A} \]

Gage Factor

Wheatstone Bridge Circuit

http://www.vishay.com/brands/measurements_group/guide/ta/ftm/ftmi.htm
Quarter Bridge Circuit - Bending

- Simplest
  - Not recommended!

\[ \frac{B_B}{B_i} = \frac{F \epsilon}{4 + 2F \sigma} \]

http://www.vishay.com/brands/measurements_group/guide/ta/fm/ftma.htm

Half-Bridge Circuit

- Bending
  - Gages in adjacent legs

\[ \frac{V_0}{V} = \frac{F \epsilon_1}{2} = \frac{F3PL_{\sigma_i} \left[ 2 - \frac{L}{L_B} \right]}{EBt^2} \]

Full-Bridge Circuit - Bending

- Maximum sensitivity
- Temperature compensation

\[ V_0 \quad V = F_{\varepsilon_1} = \frac{F6PL_\theta \left[ 2 - \frac{L}{L_\theta} \right]}{E_b r^2} \]


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Full-Bridge Circuit – Axial Loading

\[ \frac{E_p}{E_i} = \frac{F \varepsilon \left( 1 + \nu \right)}{2 + F \varepsilon \left( 1 - \nu \right)} \]

http://www.vishay.com/brands/measurements_group/guide/ta/ftm/ftmf.htm

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Torque Measurement with Strain Gages

- Torque measurement with strain gages

![Torque Measurement Diagram](http://www.vishay.com/brands/measurements_group/guide/ta/msg/msg25.htm)

Pressure sensing with strain gages

- Pressure sensor using strain gages and thinned tube

![Pressure Sensor Diagram](http://www.vishay.com/brands/measurements_group/guide/ta/msg/msg31.htm)

Where:

- $P =$ internal pressure
- $R =$ mean radius
- $t =$ pipe thickness in thinned section

$$\varepsilon_1 = \frac{PR}{2A} \left(1 - 0.5\nu\right) \times 10^6$$

$$\varepsilon_2 = \frac{PR}{8A} \left(0.5 - \nu\right) \times 10^6$$

$$\frac{V_1}{V} = \frac{R\theta_1(1+\nu) \times 10^3}{4 - 3\nu - 5P\theta_1(1-\nu) \times 10^5}$$

Where:

- $P =$ internal pressure
- $R =$ mean radius
- $t =$ pipe thickness in thinned section
Diaphragm Pressure Sensor

- Diaphragm pressure sensor using strain gages

Strain Gage Rosettes

- To measure general states of stress

http://www.vishay.com/brands/measurements_group/guide/ta/msg/msg33.htm

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Strain Gage Selection

1. Gage Length
2. Gage Pattern
3. Gage Series
4. Options
5. Gage Resistance
6. S-T-C Number

S-T-C Number

- **S-T-C (Self-Temperature-Compensation)**
  - Special processing of alloy to minimize temperature induced apparent strain

[Diagram showing temperature versus thermal strain for different alloys]

http://www.vishay.com/company/brands/measurements-group/guide/ti/ti505/505tec.htm