The Application of Strain Gauges to Composites

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Introduction

- Requires special considerations
  - Strain gauge selection
  - Adhesive selection
  - Surface preparation
  - Instrumentation
  - Special applications

Strain Gauge Selection

- Gauge Type
- Size
- Resistance
- STC (Self Temperature Compensation)

Gauge Type

- Encapsulated Gauge Ideal
  - Easier to handle and solder
- Open Faced
  - Lower reinforcing effect
    - Use on thin or low-modulus materials
- Pre-Leaded
  - Highly heat-sensitive materials
    - Reduced installation flexibility
    - May compromise glueline thickness

Gauge Type

- Strain Range
  - 3 to 5% typical for constantan STC foil
  - Up to 20% for annealed constantan
- Fatigue Life
  - Karma
  - Iso-elastic

Size

- Fits on Specimen
  - Matrix size, not grid size!
- Gauges Detect Average Strain Under Grid
  - Grid length/width
  - Consider weave size
    - 5 x aggregate is a good guide
- 6mm Grid Length Considered Optimum in Many Cases

Resistance

- Poor Heatsink
  - Low thermal mass
  - Low thermal conductivity
- Gauge Self-Heating
  - Grid power density
    - 350 ohms minimum
    - 1000 ohms becoming more popular

STC
(Self Temperature Compensation)

- Thermal Output
  - Match to substrate material
    - TCE of substrate must be known
    - Composites are directional!
- Use Stock Gauges
  - 06 (steel) and 13 (aluminium) common
  - 00 stocked in popular patterns

Adhesive Selection

- Surface Finish
- Temperature
- Test Duration
- Installation Requirements

Surface Finish

- Smooth Surface
  - Install gauge directly onto surface
- Textured Surface
  - Adhesive must gap-fill
    - 2-step installation process

Cyanoacrylates

- Instant
  - Short term only (9-12 months max)
  - Will not gap-fill
  - -25 to +65 normal use
  - 3 to 5% or higher elongation
- Be Wary of Generic Cyanoacrylates
  - Use strain gauge certified adhesives only

Epoxy (100% solids)

- Wider Temperature Range
  - -195 to +95°C (room temperature cure)
  - As wide as -269 to +300°C
- Gap Filling Capability
  - Both filled and unfilled are suitable
  - Use on textured surfaces

Epoxy (100% solids)

- Some Require Heat Curing
  - As low as 50°C
- Long Term (Years)
  - Highly moisture resistant
- As High as 15% Elongation

Epoxy Phenolic

- Widest Temperature Range
  - -269 to +400°C
- Long Term (Years)
- Require Heat Curing
  - As low as 80°C

M-Bond 600, 610, 43B, 450

Epoxy Phenolic

- Will Not Gap Fill
  - Solvent thinned for 3-5 micron gluelines
    - Smooth composites only
- Elongation up to 4%

M-Bond 600, 610, 43B, 450

Polyester

- Special Applications Only
  - Not recommended for general-purpose use
- Room Temperature Cure
- Will Work to 150°C Without Further Curing
- Elongation up to 2%

Special Epoxy

- Special Applications Only
  - Not recommended for general-purpose use
- High Elongation
  - Up to 20%
- Requires Special Usage Considerations

Surface Preparation

- Degrease
  - –Check for compatibility
    - •Many aerosols will attack material
    - •IPA safe on many plastics
  - –Be aware of release agents
    - •Silicone oils are difficult to remove
      - –Heated acidic solution required

Surface Preparation

- Abrade
  - Smooth
    - 320 or 400 grit
  - Textured
    - Air abrade
    - Brush/paste
  - Special
    - Pumice powder and cotton bud

Instrumentation

- Variable Bridge Excitation
  - –Minimise grid power density
    - •2V maximum
- Should Accept Common Resistances
  - –350 ohms
  - –1000 ohms
  - –500 ohms (more on this later!)

Special Applications

- High Cyclic Fatigue
- Avoiding Localised Failure
- Ultra-High Elongation (>20%)
- Shear Modulus Testing

High Cyclic Fatigue

- Metallic Gauge Will Fail Eventually
  - Constantan – lowest fatigue rating
  - Karma – significantly better fatigue life
  - Iso-elastic – better fatigue than Karma
- ‘Reference’ Gauge
  - Relate two gauges, one in lower strain area
- Re-Install Gauges at a Convenient Point in Test

Localised Failure

- Single-Strand Failure Causes High Localised Strain
  - Strain gauge fails with no indication of high strain
    - Gauge detects average strain
- Mitigate Strain Level
  - Apply Kapton film layer under gauge

Ultra-High Elongation

- Gauges and Adhesives up to 20% Strain Only
  - Use extensometer
    - Displacement sensor
    - ‘Top hat’ cross-section with strain gauge on top

Shear Modulus Testing

- Iosipescu and Compact Specimens
  - Non-uniform strain between notches
    - Unreliable results from conventional patterns
      - Can be as much as 30% error!
  - Average strain required
    - Strain gauges give average strain automatically!
  - Special patterns available
    - 500 ohms
      - Use as quarter or half bridge

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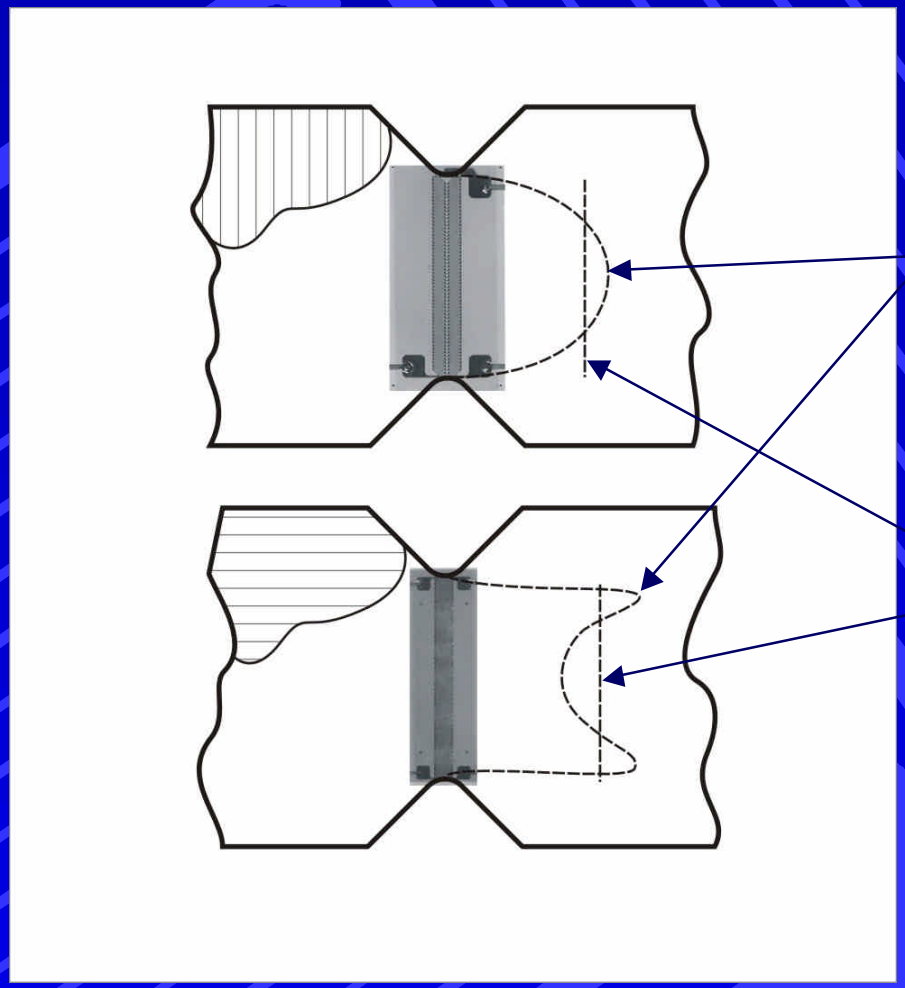
BSSM
BRITISH SOCIETY FOR STRAIN MEASUREMENT

Shear Modulus Gauges

90°
Fibres



0°
Fibres

QUESTIONS?

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