

Evaluation of Fiber-Optic Loop Sensor Mounting on Laminated Glass Fiber Composites Based on Power Modulation

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Objectives

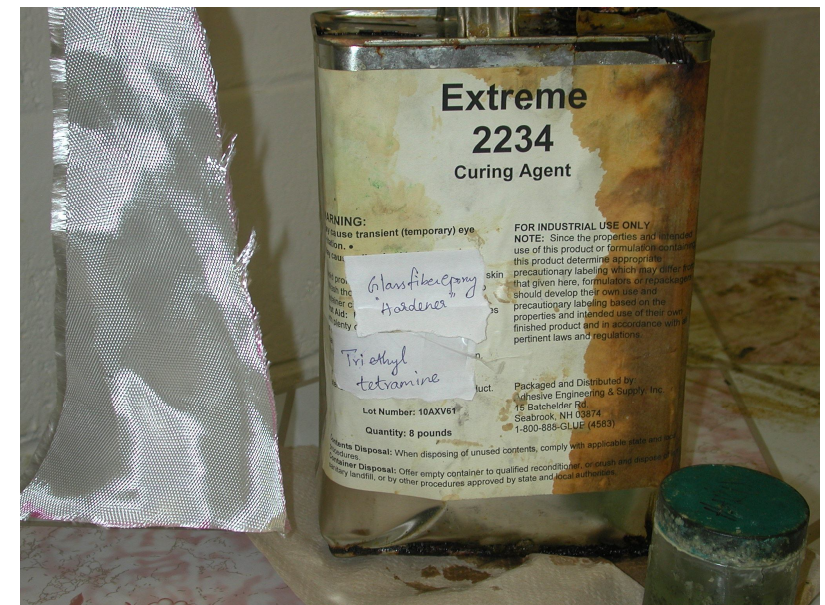
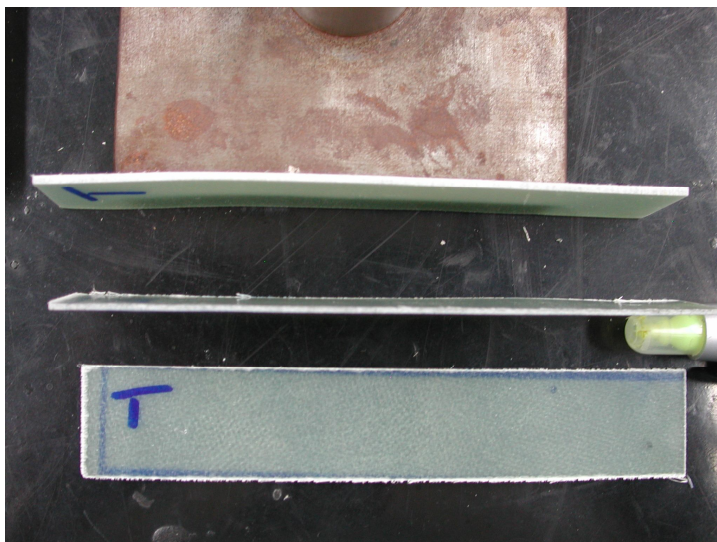
- Use a fiber optic loop as a sensor
 - Measure intensity losses and calibrate with load and deflection of a composite material
- Evaluate fiber optic loop sensor configurations
 - Repeatability
 - Sensitivity

Outline

- Fabricated laminate composites
- Three point bending test
 - Quasi-static testing
 - Young's modulus
- Tested eight loop sensor configurations
 - Optical intensity / Load testing
- Limited repeatability
 - Normalize the data
- Areas of further study

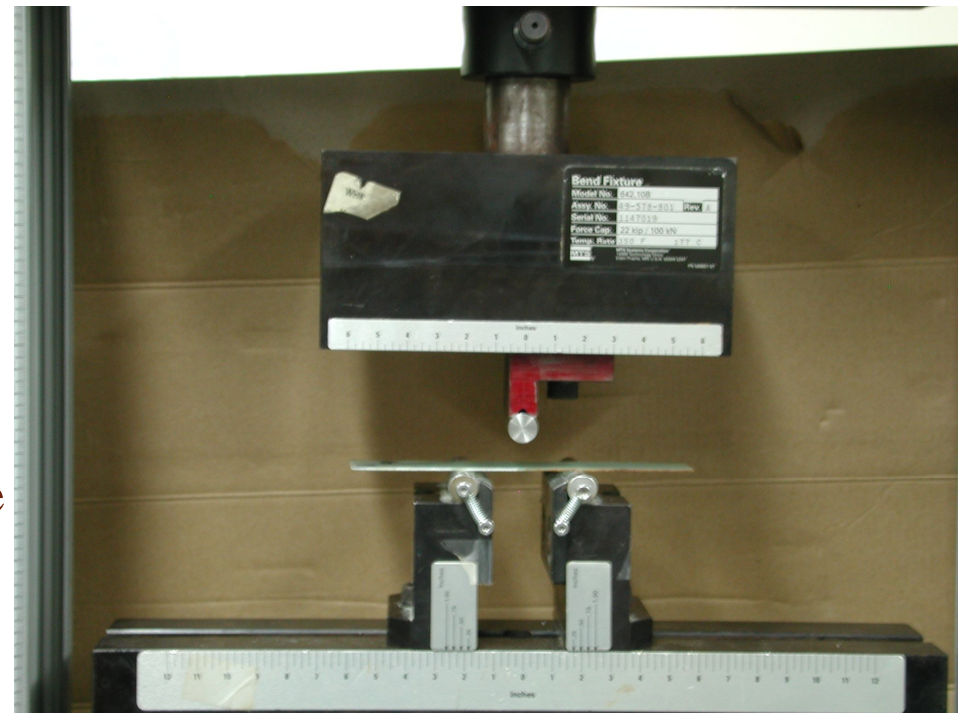
Composite Fabrication

- Angle orientation
 - $0^\circ / 90^\circ$; $15^\circ / 75^\circ$; $30^\circ / 60^\circ$; $\pm 45^\circ$
- 4 Layer / 8 Layer
 - Tk ~1mm ~2 mm
- Epoxy resin / Hardener
- Samples 1" BY 6"



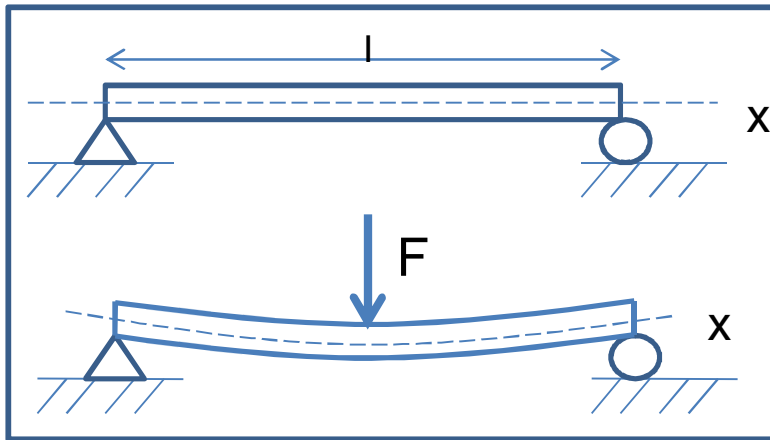
Composite Testing

- Three point bending
 - Quasi-static test
- Young's modulus
 - $E = L^3 D / 48 I$
 - $D = \text{load verses deflection slope}$
 - $L = \text{span}$
 - $I = \text{Moment of inertia (mm}^4\text{)}$
 $I = \{b h^3 / 12\}$
 - $b = \text{width}$ $h = \text{height}$

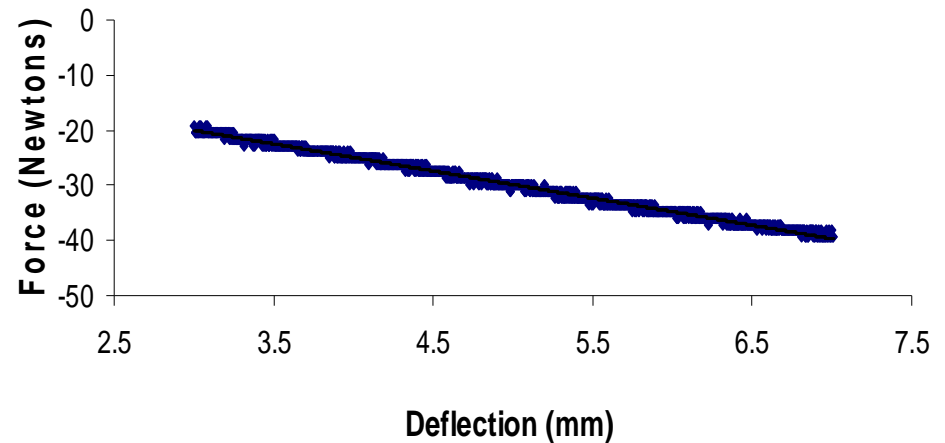


Three Point Bending

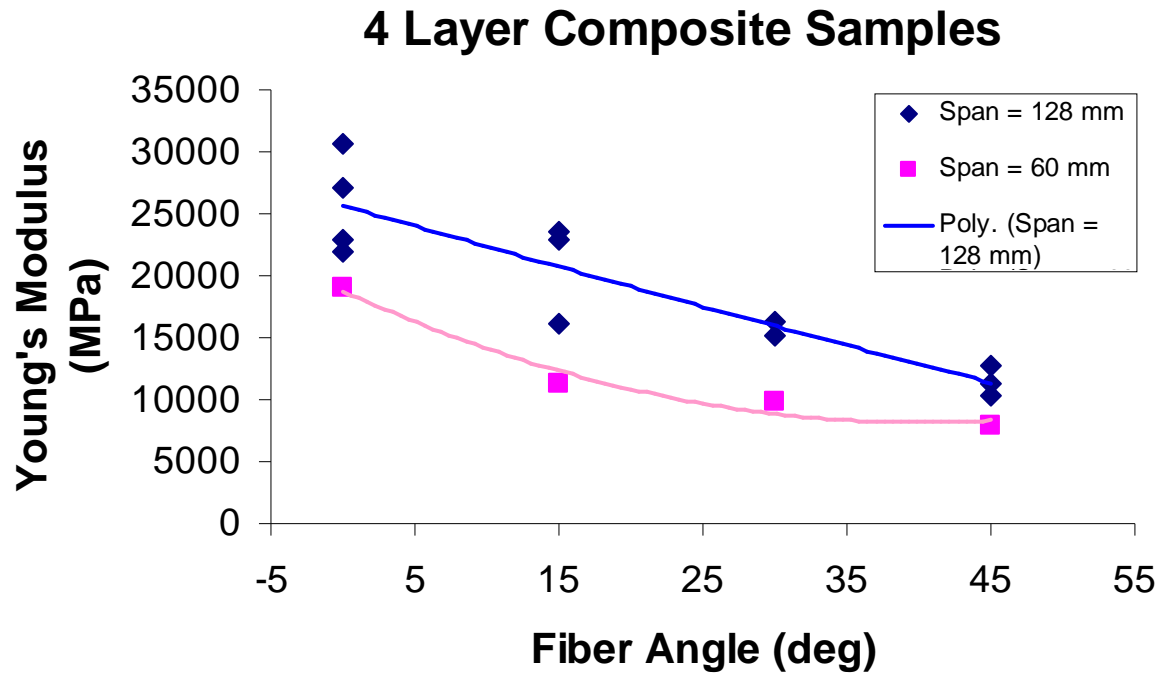
- Instron 4469 span 60mm ; 128 mm
- 50 kN load cell



4 Layer 15-75 Deg
Span = 60mm

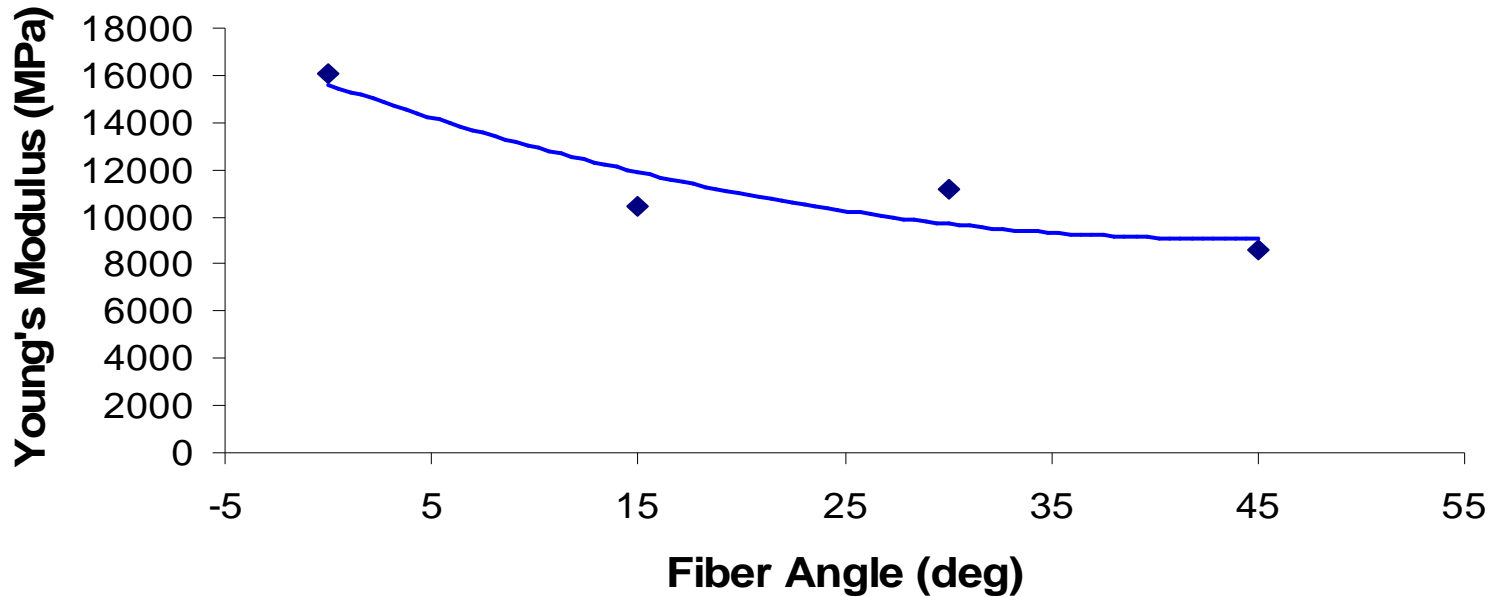


Young's Modulus



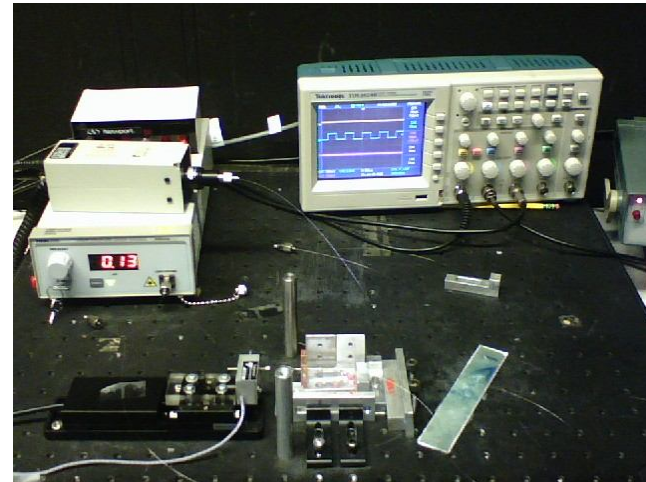
Young's Modulus

8 Layers Composite Samples Span = 60 mm



Optical Fiber Testing

- Fiber connectors
- Fiber in test stand
- Translation stage
- Load cell
- Laser source to optical detector



Data Acquisition

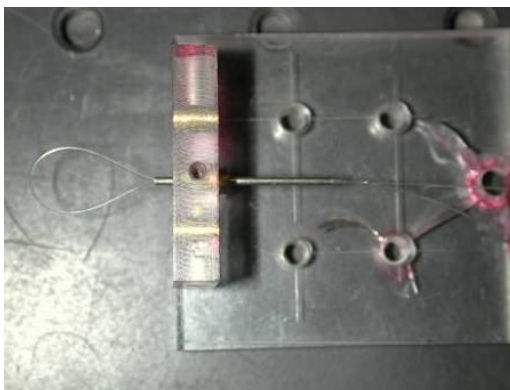
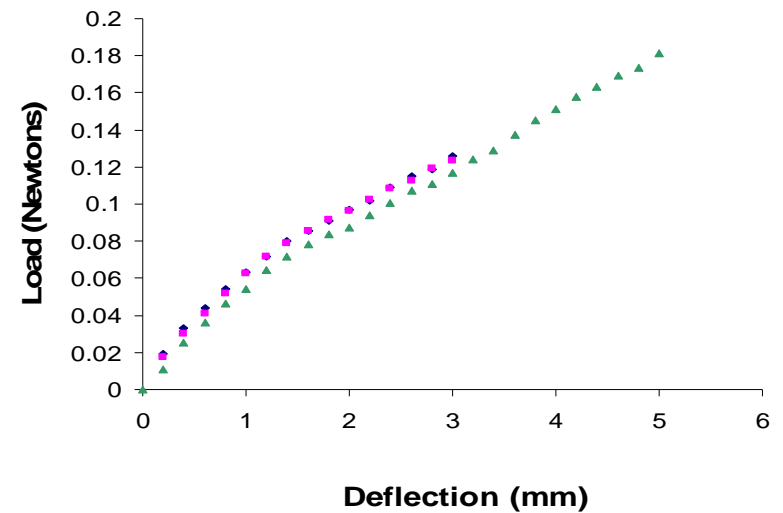
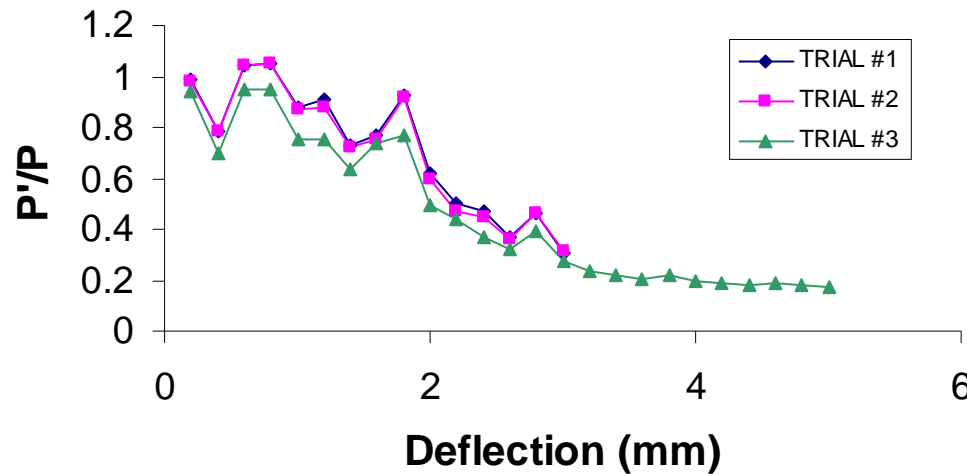
- Apt motor controller
 - Deflection (mm)
- Labview (Signal Express) and oscilloscope
 - Load (mVolts)
 - Optical signal (mVolts)

Results of Tested Configurations

- Eight fiber loop sensor configurations
 - Loop in free space
 - Attached fiber to sample
 - loop
 - ellipse
 - Through a hole
 - Weaved into sample
 - Loop behind sample
 - test jig

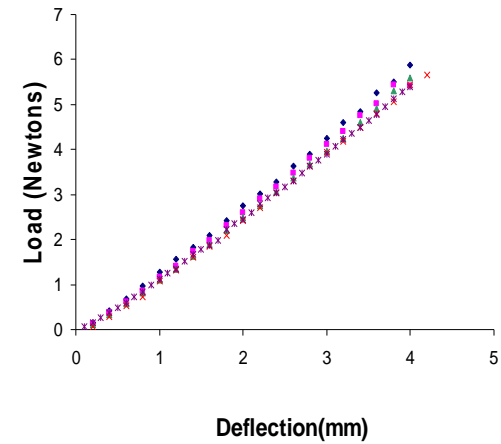
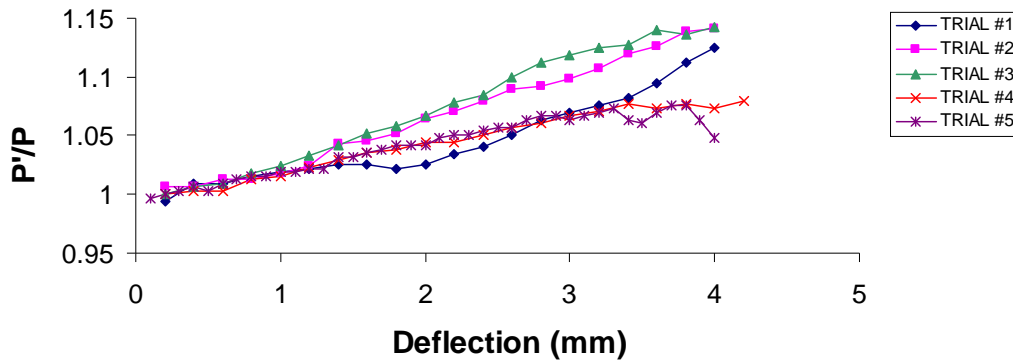
Loop in Free Space

Test Configuration 1 5mm Loop Placed in Free Space Loaded Parallel to Major Axis of Loop



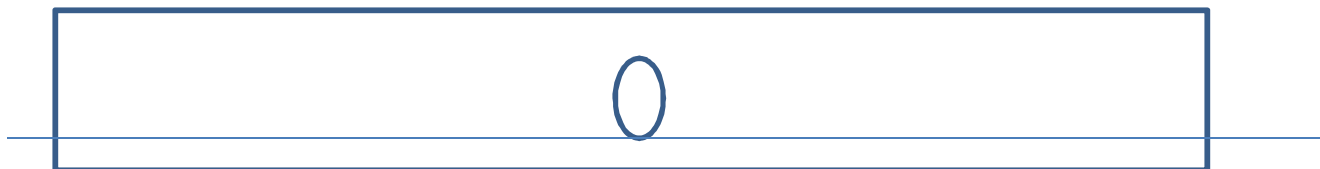
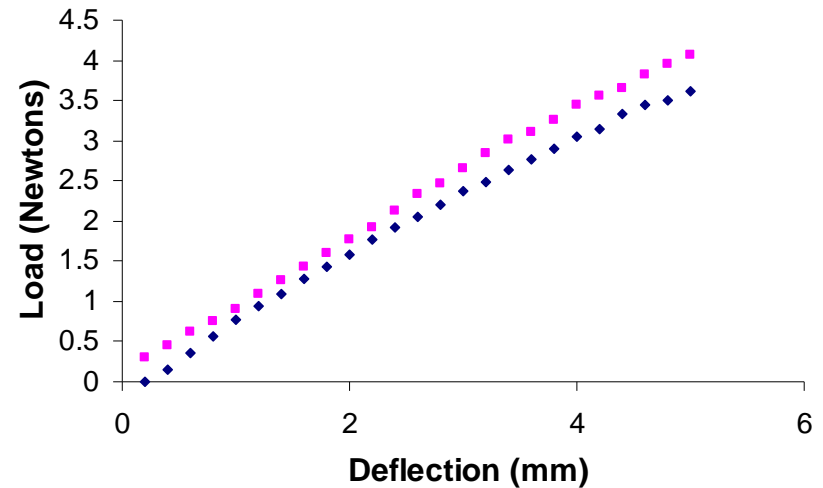
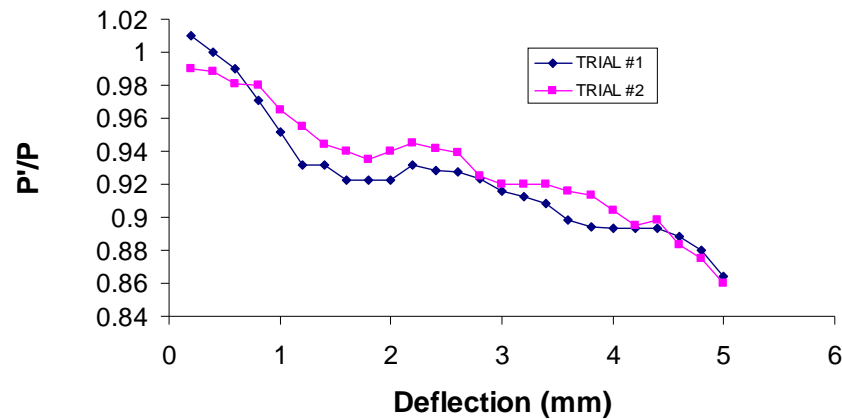
Weaved Fiber

Test Configuration #5
Weaved Through Two Holes .5 inches apart Middle Loop R
= 2.71 mm Outer Loops
R = 2.3mm 4 Layer 15-75 deg Laser = .13mW

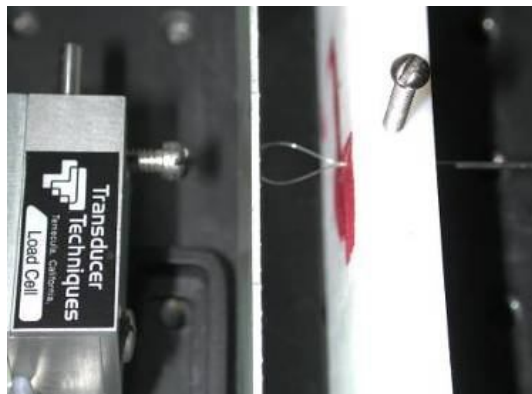
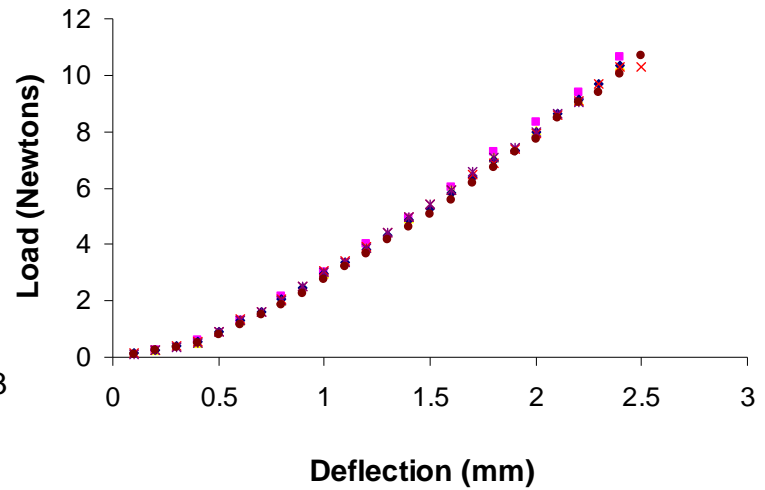
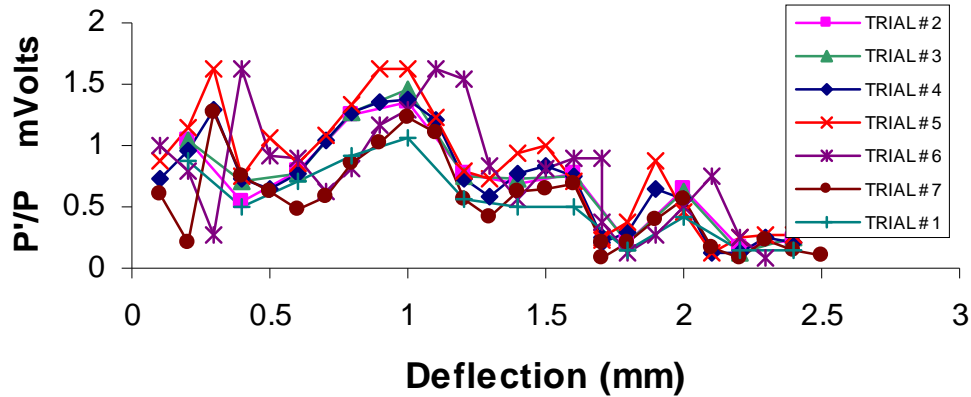


Vertical Ellipse

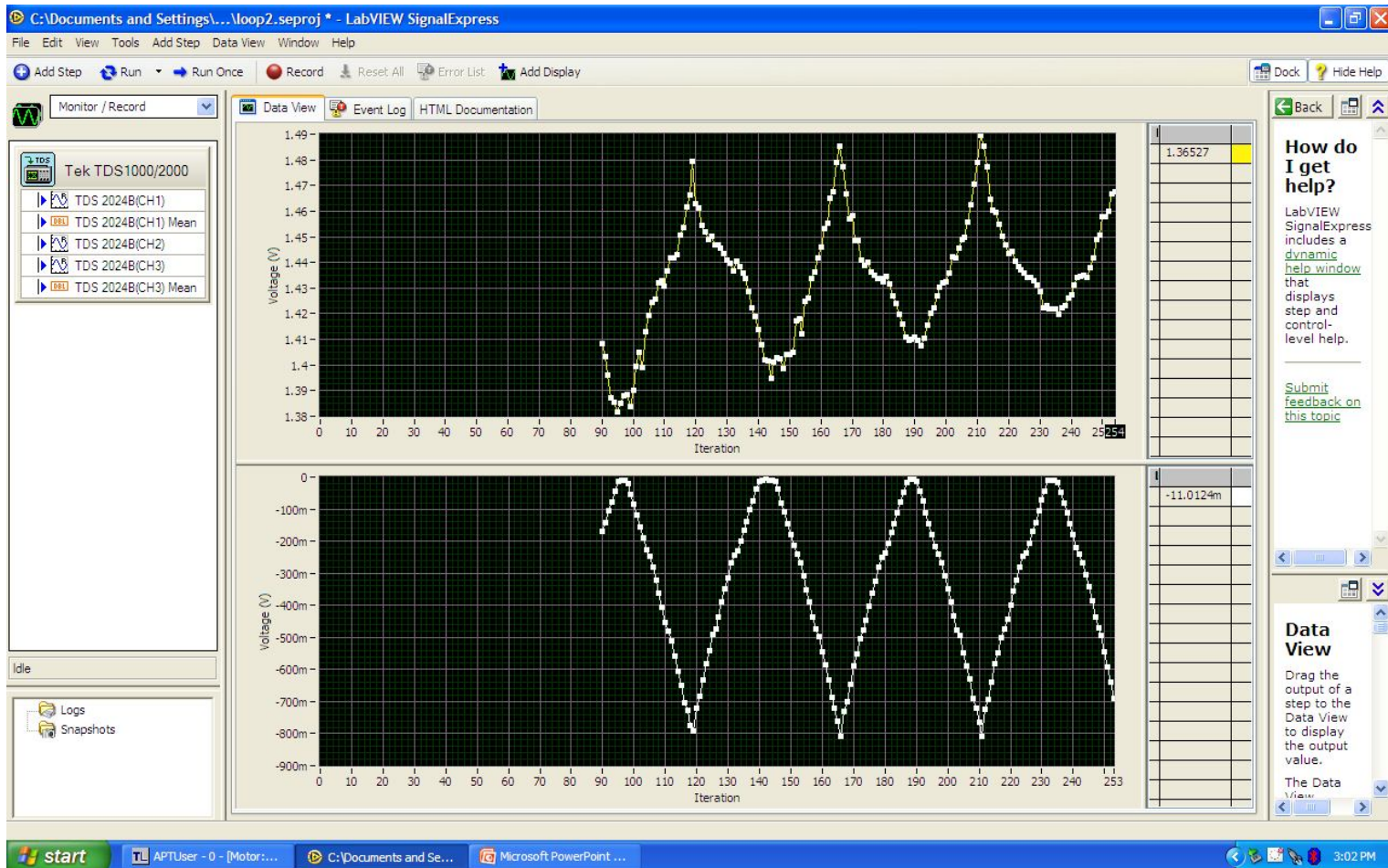
Test Configuration #2
5 mm Loop in a Vertical Ellipse (Minor dia=7.42mm)
Parallel to Surface of Composite 4 Layer +/- 45 deg Laser = .13 mW



Test Jig



Sample Signal Express Data



Data Analysis

- Load data repeatable
 - Slight shifts
- Optical data
 - Shift in magnitude
 - Lateral shifts
 - Initial state
 - Limited repeatability (strain guage)

Limited Repeatability

- Variation in laser intensity
- Variation in optical detector
- Optical connectors
- Data spikes (filter)
- Samples deform (aluminum/ steel)
- Temp effects
- Wear in

Conclusions

- Free space 5mm loop
 - Very repeatable response
 - Limited real world application
- Jig test -3mm – 5mm loops
 - Moderate repeatability
 - Potential sensors.
 - Greater spatial requirements
- Low profile loops
 - Limited repeatability
 - More research required

Recommendations for Further Research

- Optical signal splitter
- Stabilize the laser signal
- Filter noise
- Uniform material for initial testing

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