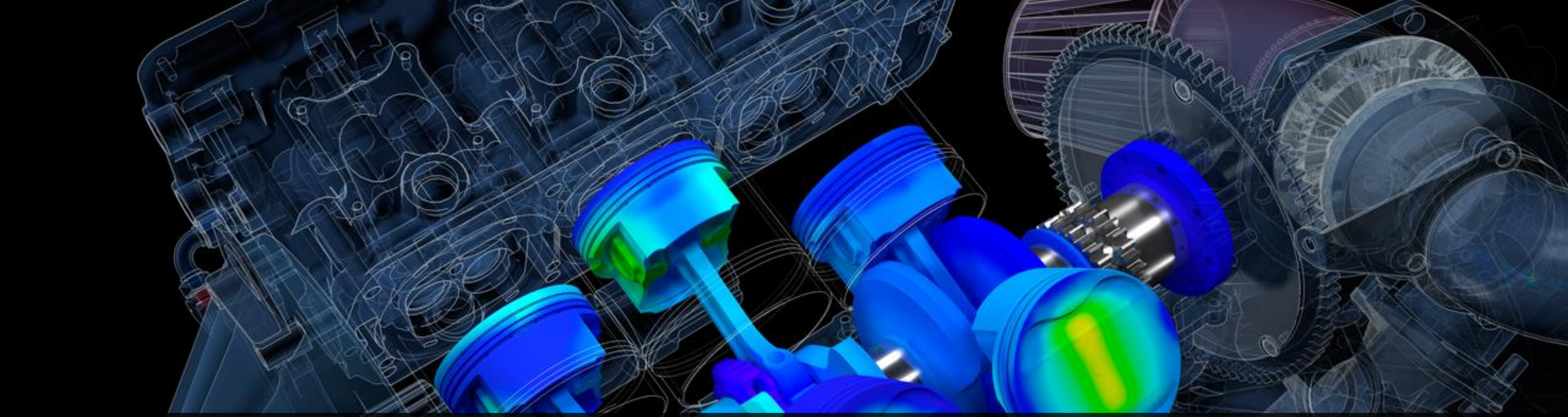

Failure Analysis of Fiber Reinforced Injection Moldings Using a Composite Lamina Approach

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Class Summary

In this class we will present to you a reasonable approach to structural analysis of fiber reinforced injection molded designs. We will also provide some insight into important parameters in the analysis that can be utilized to improve the simulation performance of your designs.

Learning Objectives

At the end of this class, you will be able to:

- Understand the importance of anisotropic structural analysis for good design
- Appreciate the need for further structural research of fiber reinforced materials
- Implement the lamina failure approach in predicting injection molded strength
- Better predict the strength of any fiber reinforced injection molded part design

Problem: Predicting Structural Integrity

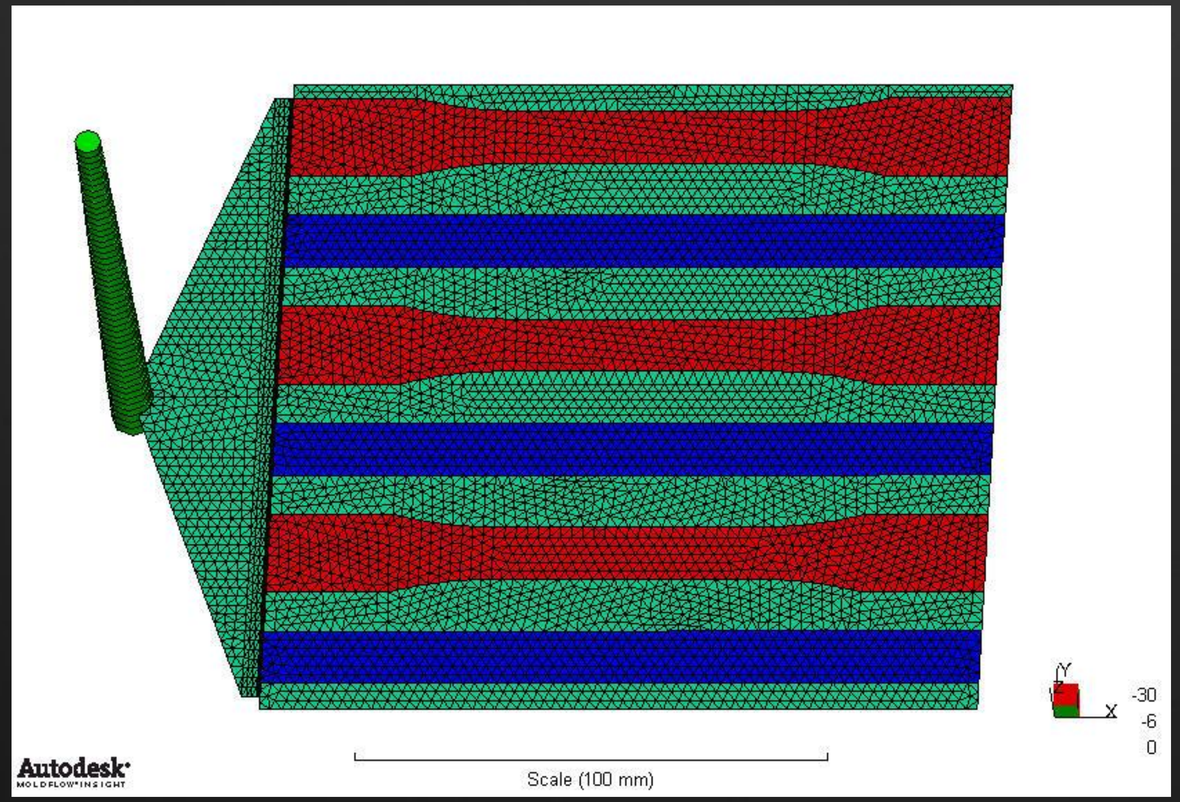
Designing with Fiber Reinforced Materials

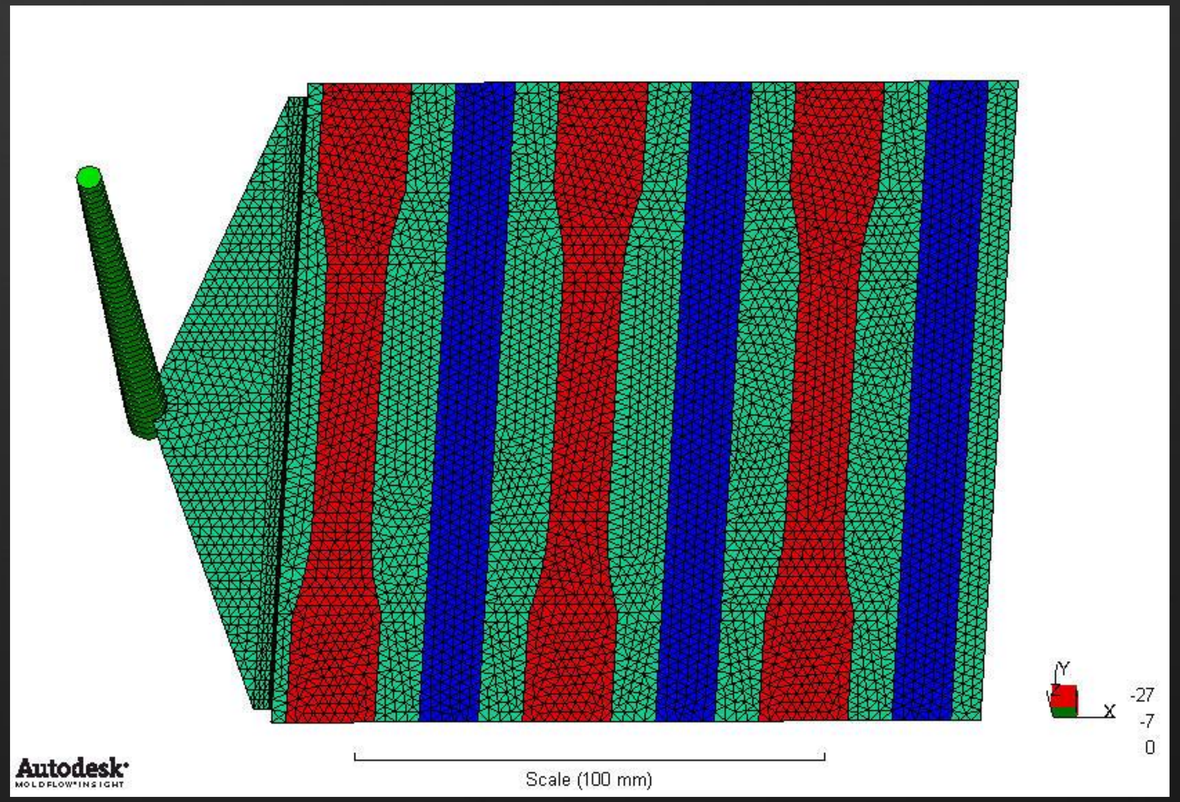
- Quasi-isotropic analysis no longer acceptable
- Everyone wants to optimize their design
  - Few engineers know ***HOW***!
- Validation of fiber orientation
  - Microscopy
  - Microtomography (Skyscan)
- New fiber orientation parameters
  - Reduced Strain Closure (RSC) model
  - Anisotropic Rotary Diffusion (ARD) model
  - Fiber aspect ratio

How can we validate fiber orientation?

- Validate orientation by micro-mechanical property predictions
- If orientation is right – stiffness and strength are right
  - Requires thickness variations and flow/cross-flow orientation
  - Some already done for mechanical properties
- Determine correlation parameters with selected materials
- Tensile modulus correlation validates intensity of orientation
- Flexural correlation validates distribution through thickness

Standard Test Panels





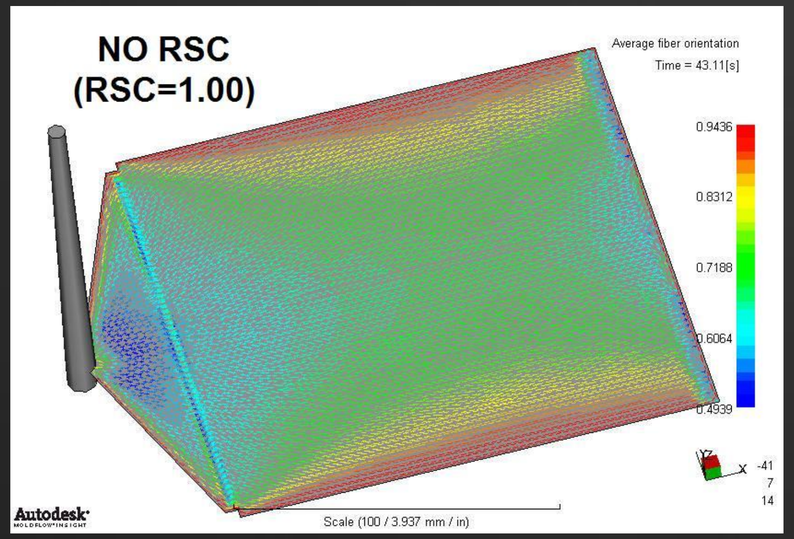
RSC Factor – Slow Orientation Dynamics

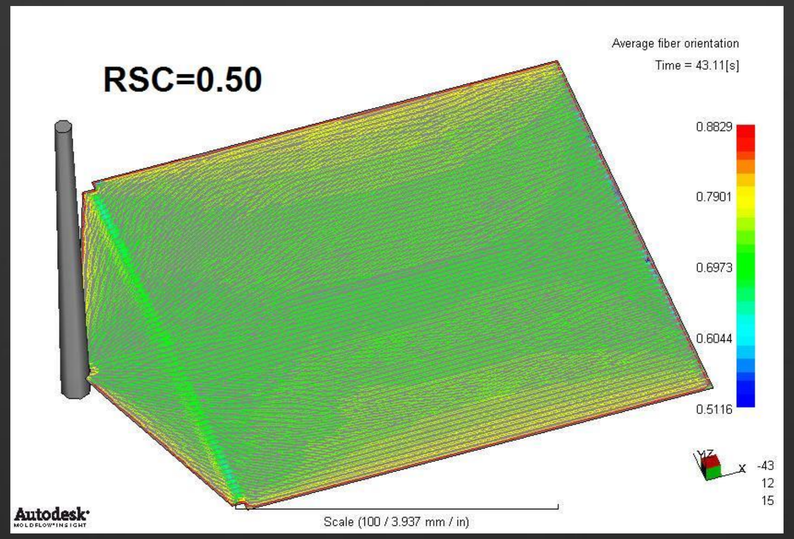
- Standard Tucker-Folgar model
  - Represents orientation in fully developed steady-state flow
- RSC factor introduced
  - Orientation requires flow history to fully develop
  - That rate may vary based on many factors
    - Polymer
    - Fibrous reinforcement
    - Reinforcement volume content
    - Others???

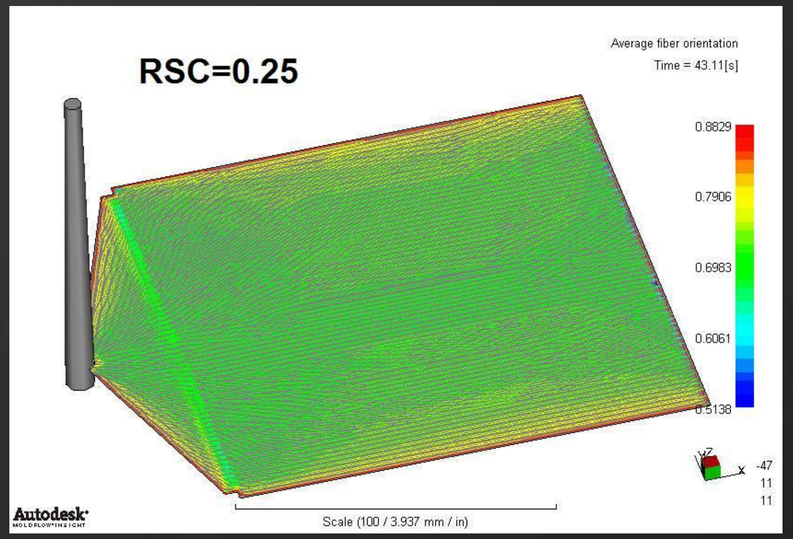
RSC Factor Presents an Opportunity !!!

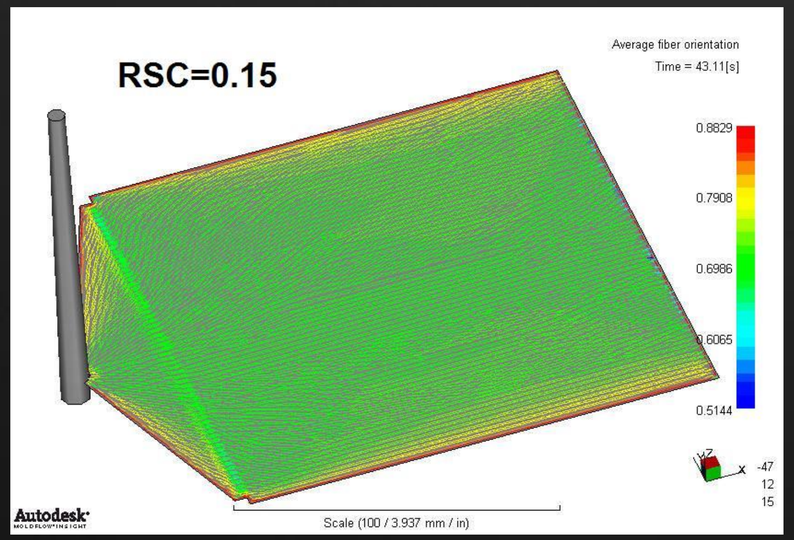
- Glass half empty (typical user's normal attitude!)
- Or, glass half full ???
- Utilize new parameter to improve the orientation correlation
- Still requires experimentation to establish
  - Possibly for all major polymer types (or classes)
  - % level of reinforcement
  - GF, CF, VLGF, VLCF

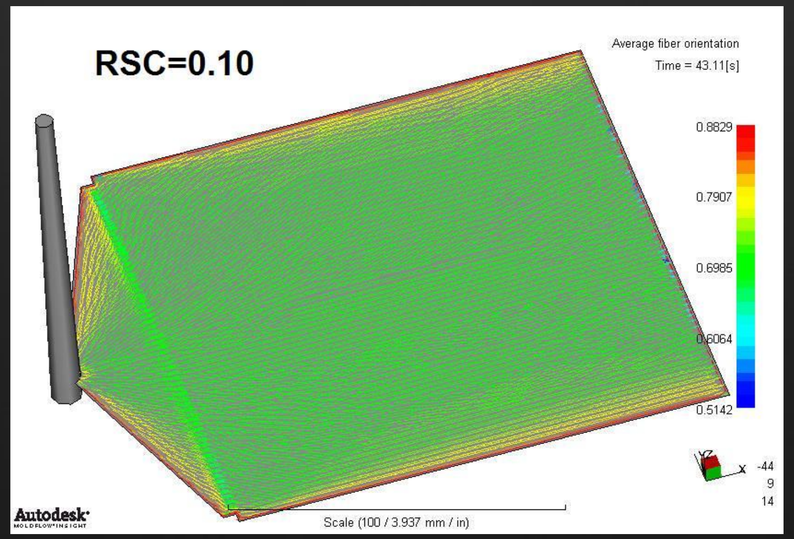
What a Difference a Factor Can Make !!!

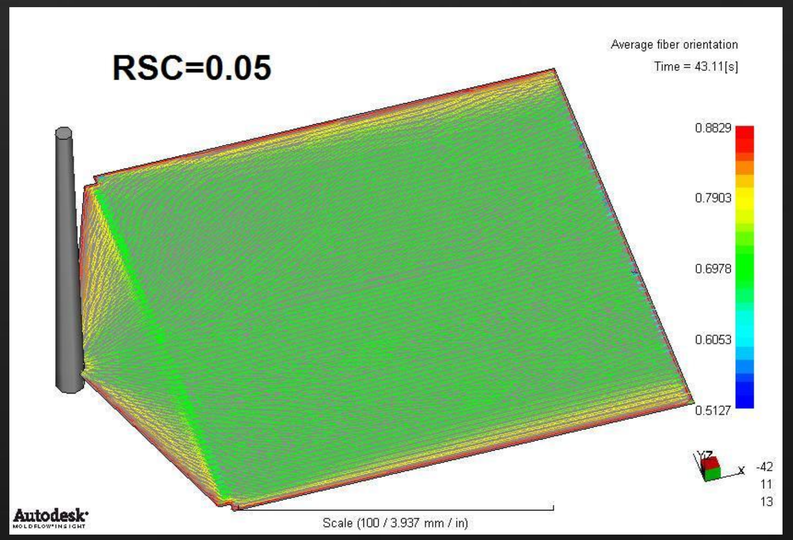






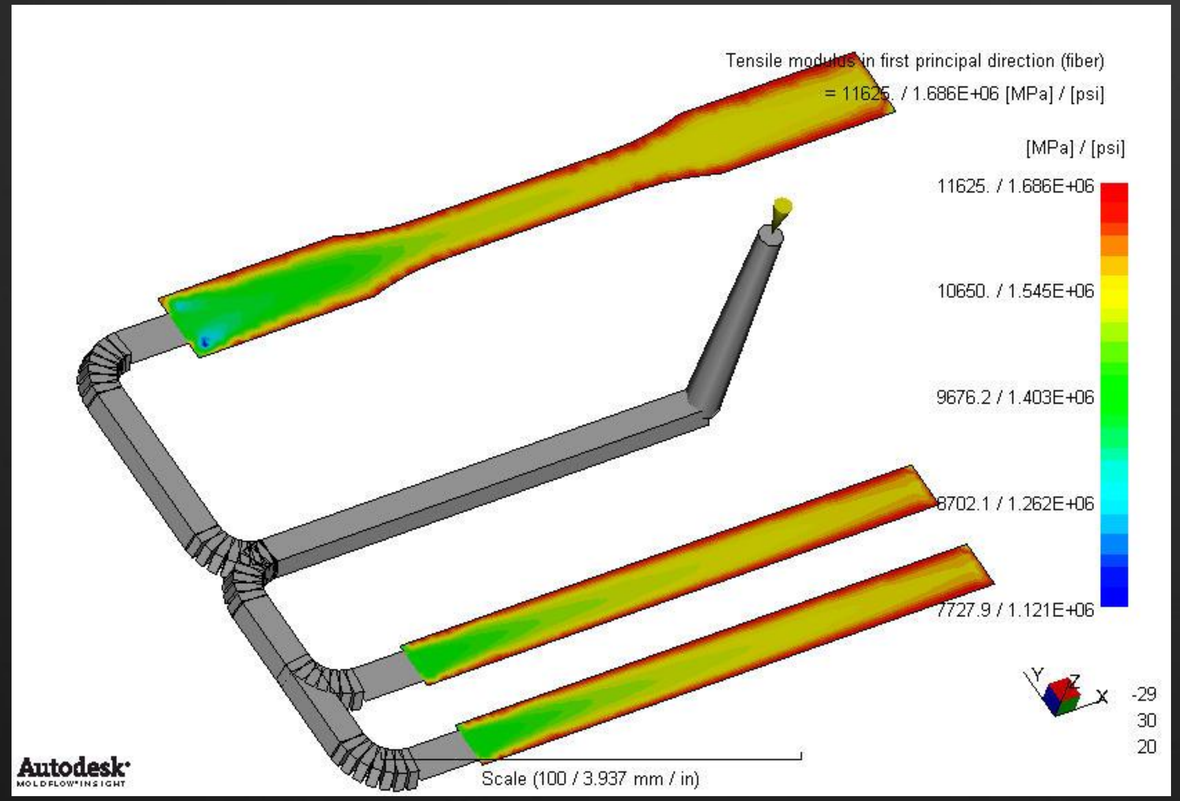


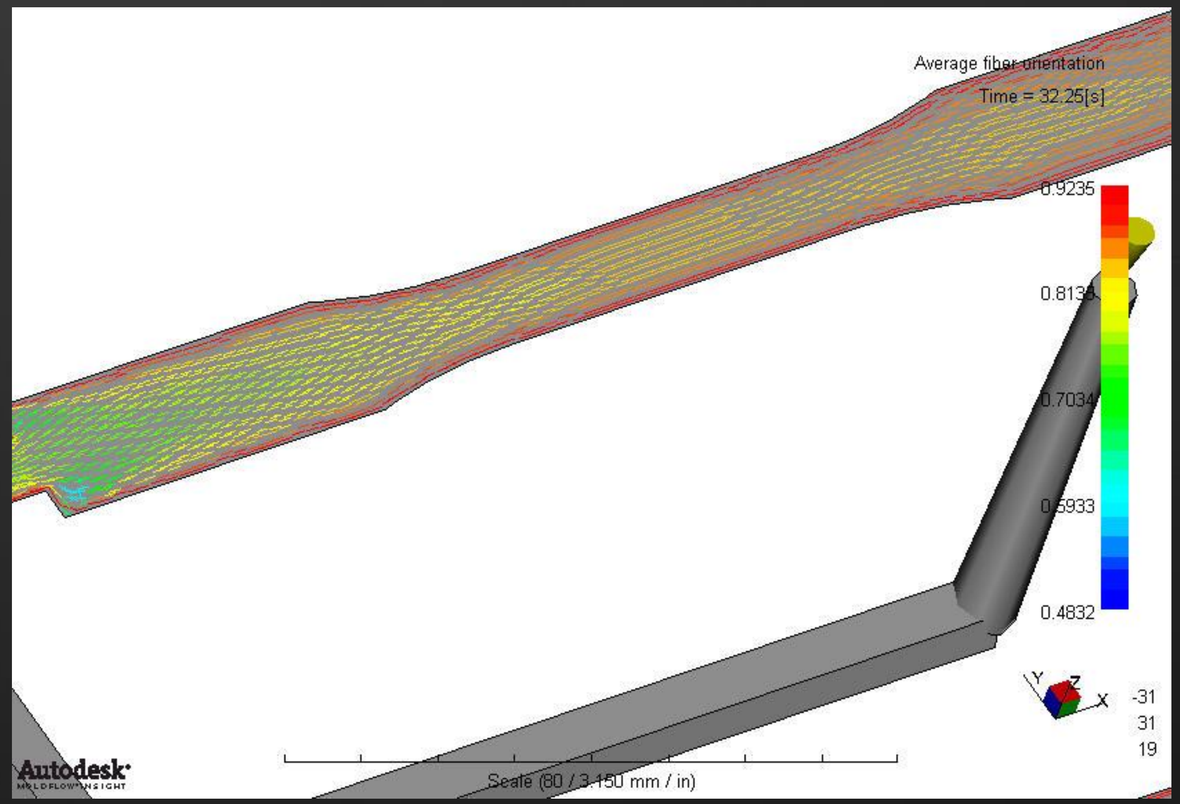




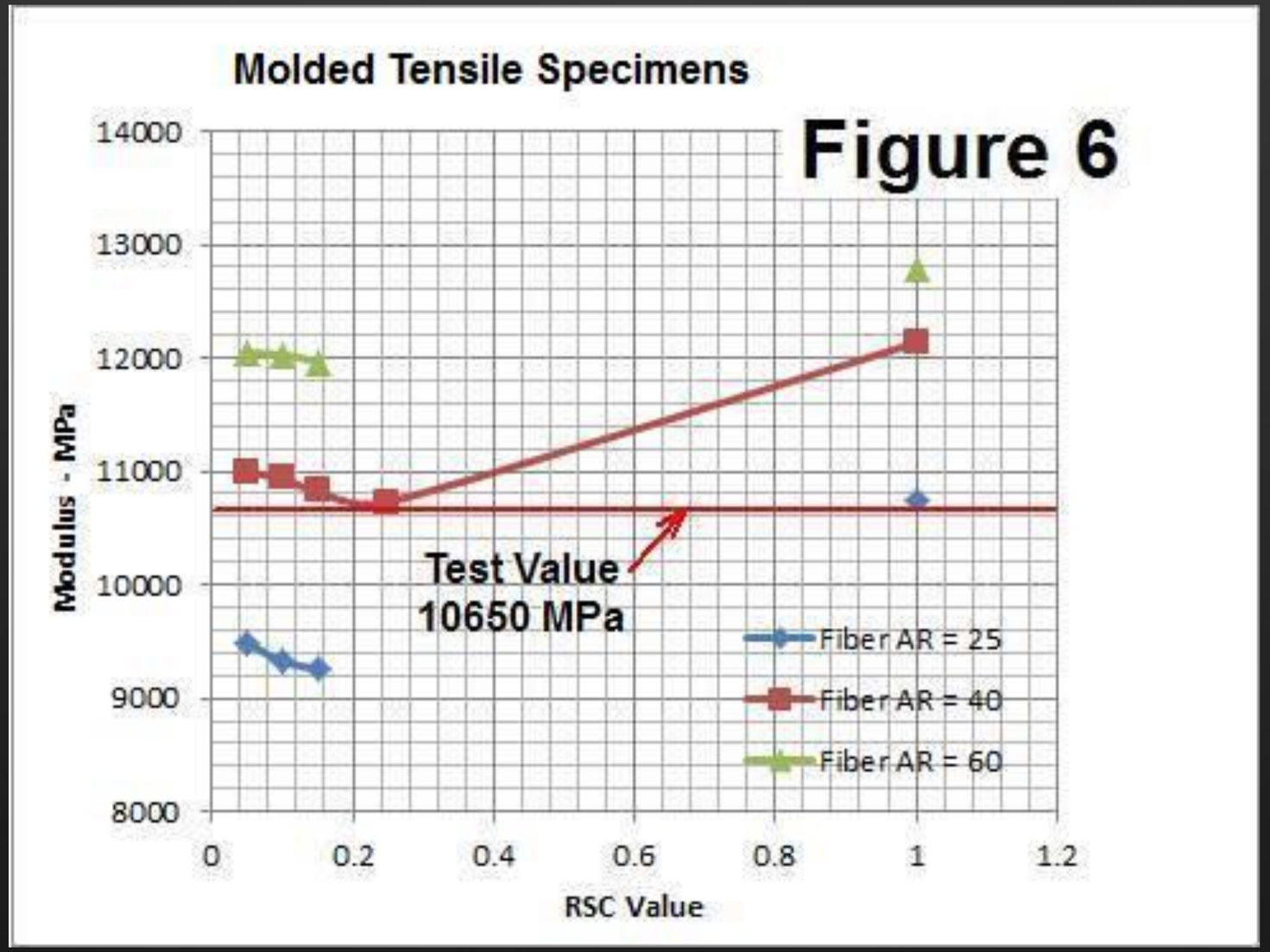
WHAT DO I DO NOW !!!!!!!

Start with Molded Specimen Orientation Validation

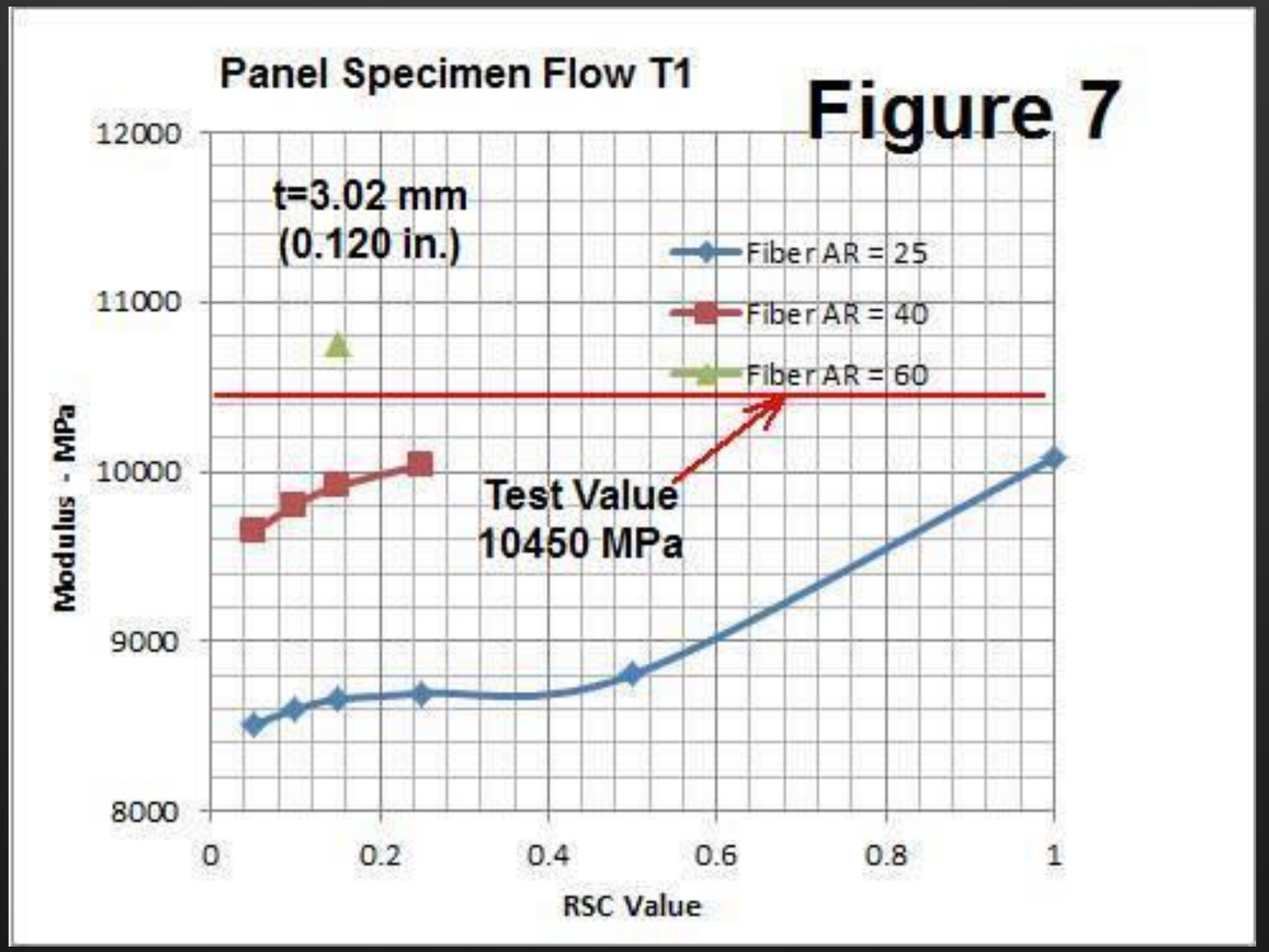




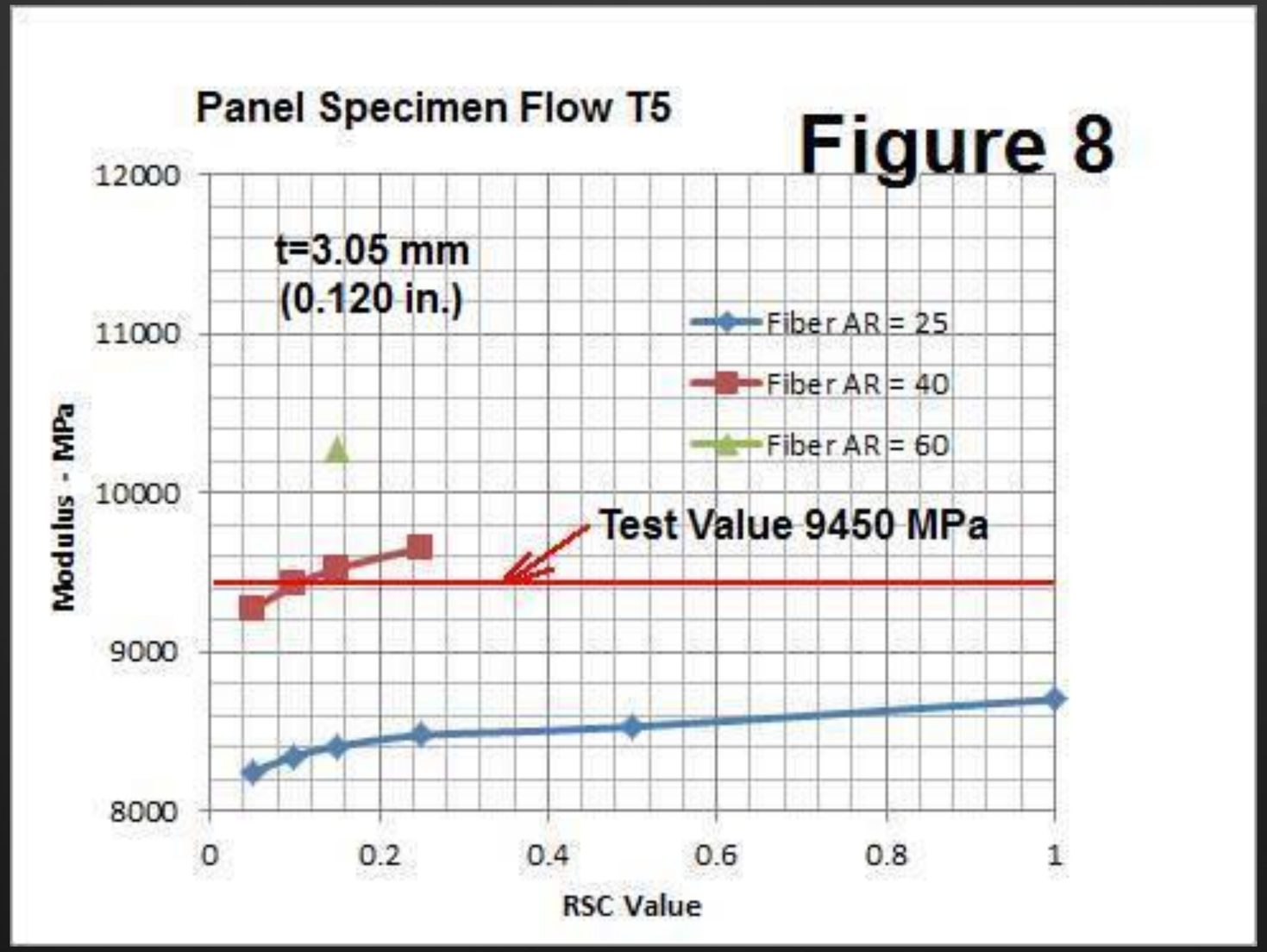
Molded Tensile Modulus vs. RSC & Fiber AR



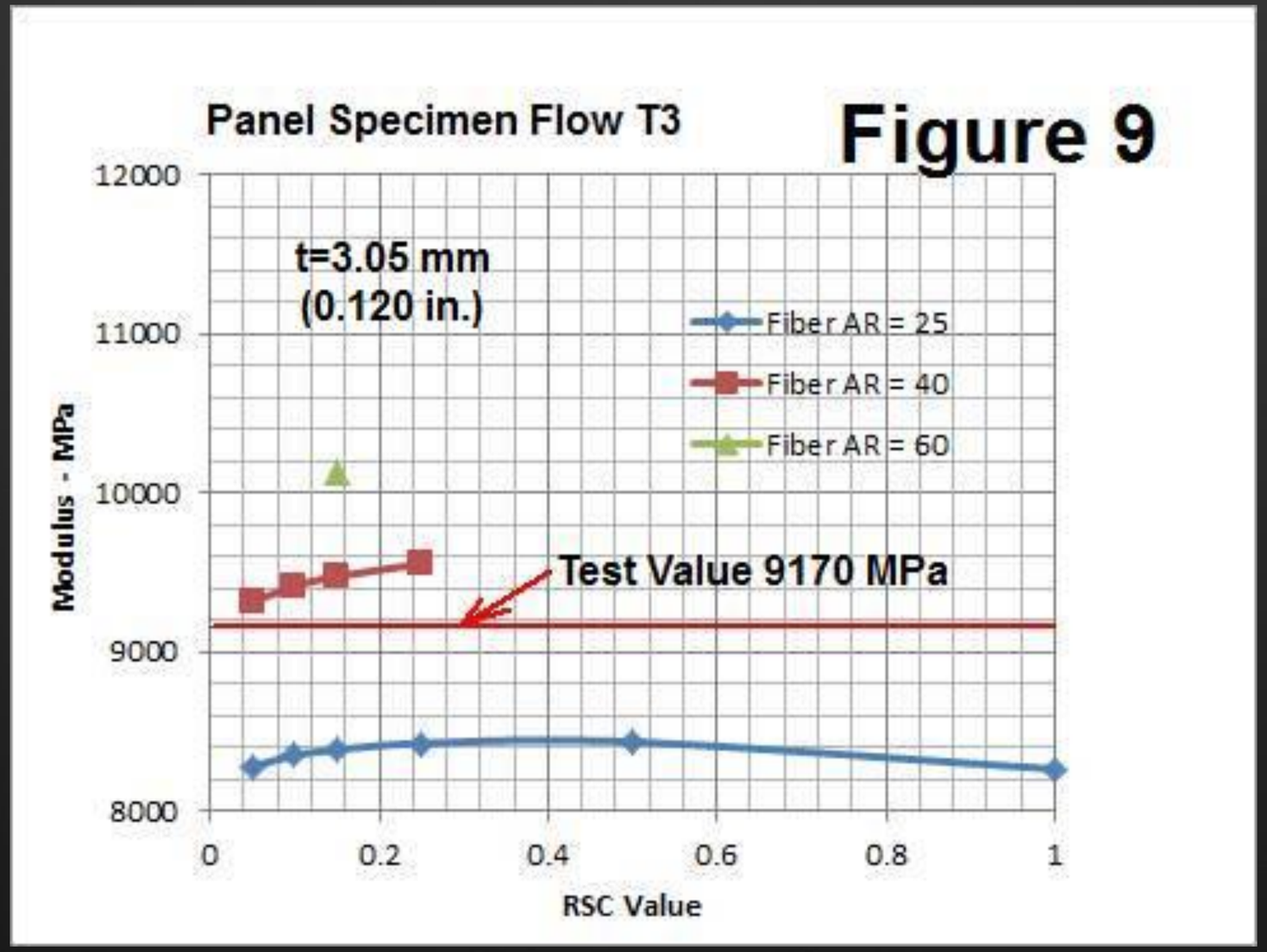
Flow Direction Modulus vs. RSC & Fiber AR (Spec. T1)



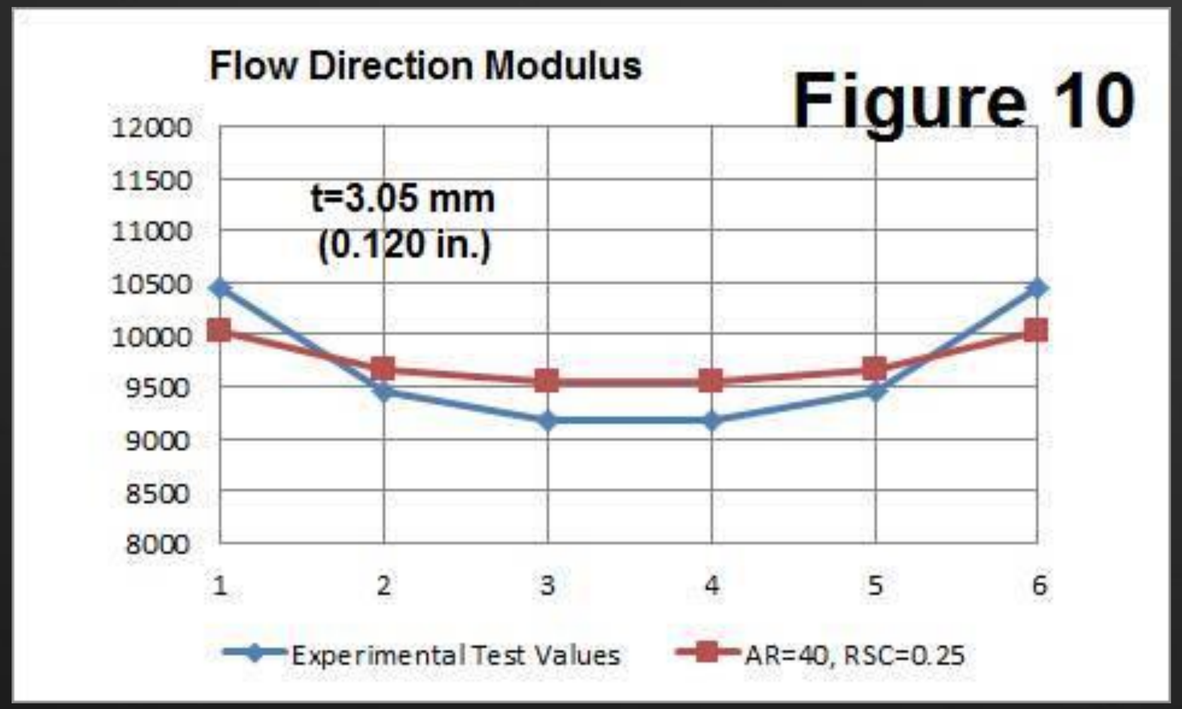
Flow Direction Modulus vs. RSC & Fiber AR (Spec. T5)

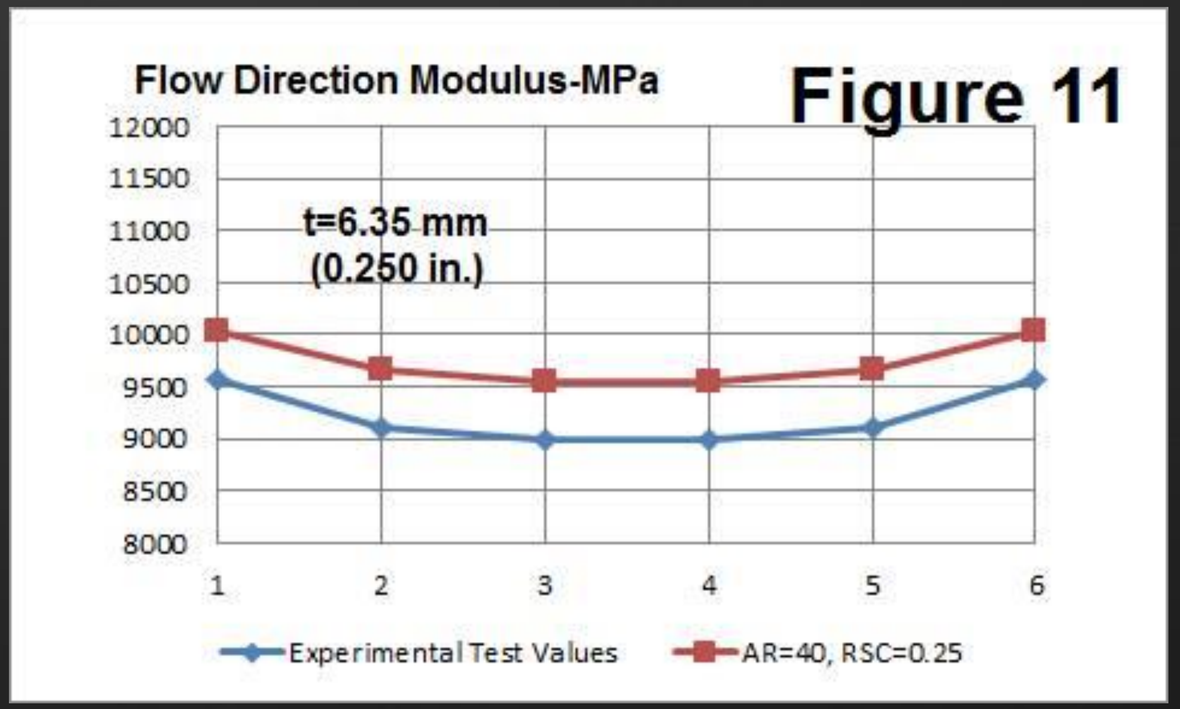


Flow Direction Modulus vs. RSC & Fiber AR (Spec. T3)



Flow Direction Modulus for RSC=0.25 & AR=40





Cross-flow Direction Modulus for RSC=0.25 & AR=40

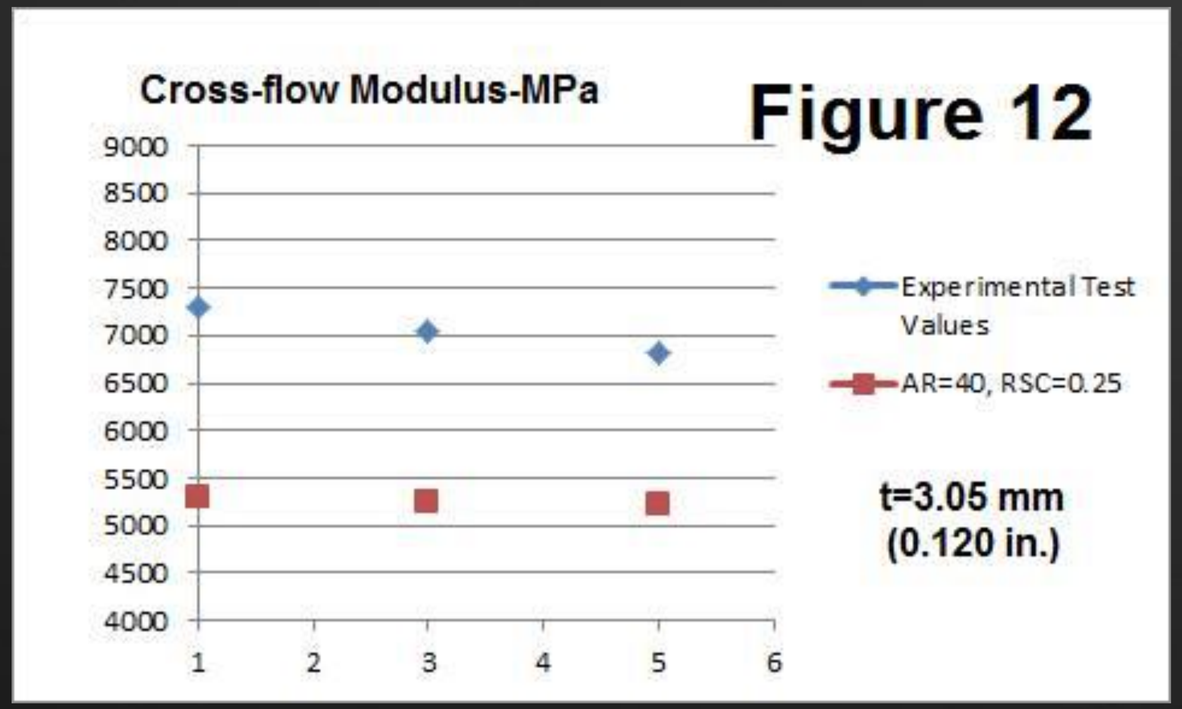


Figure 12

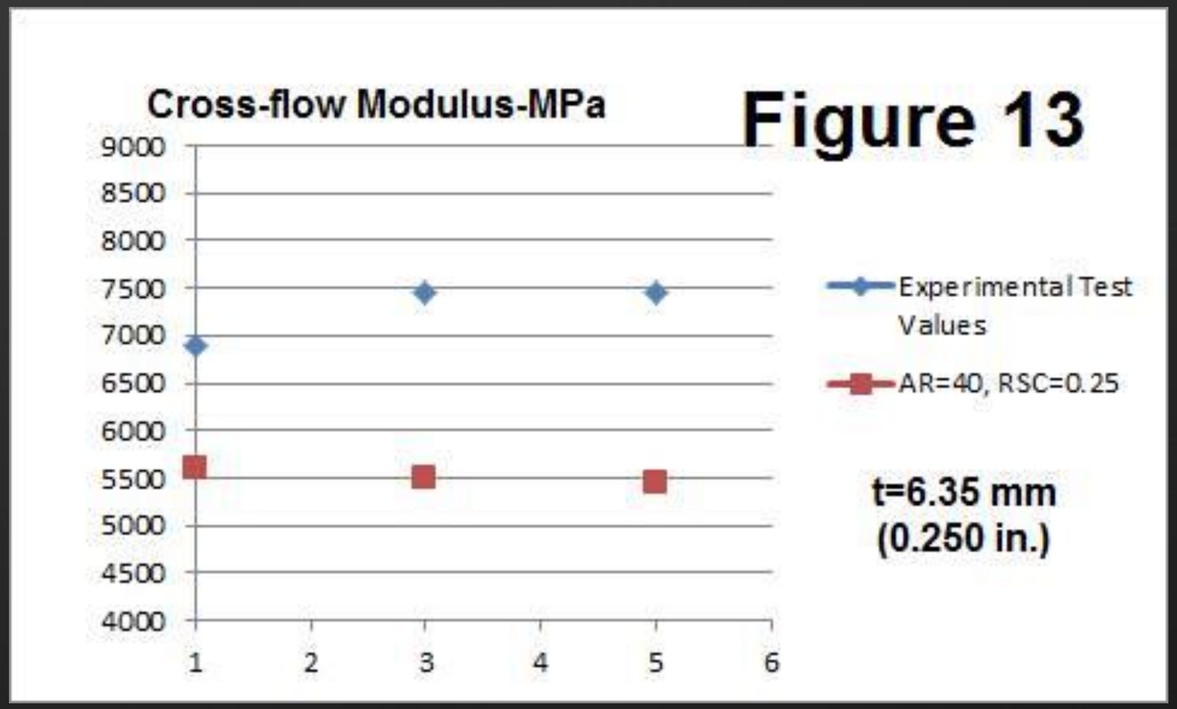


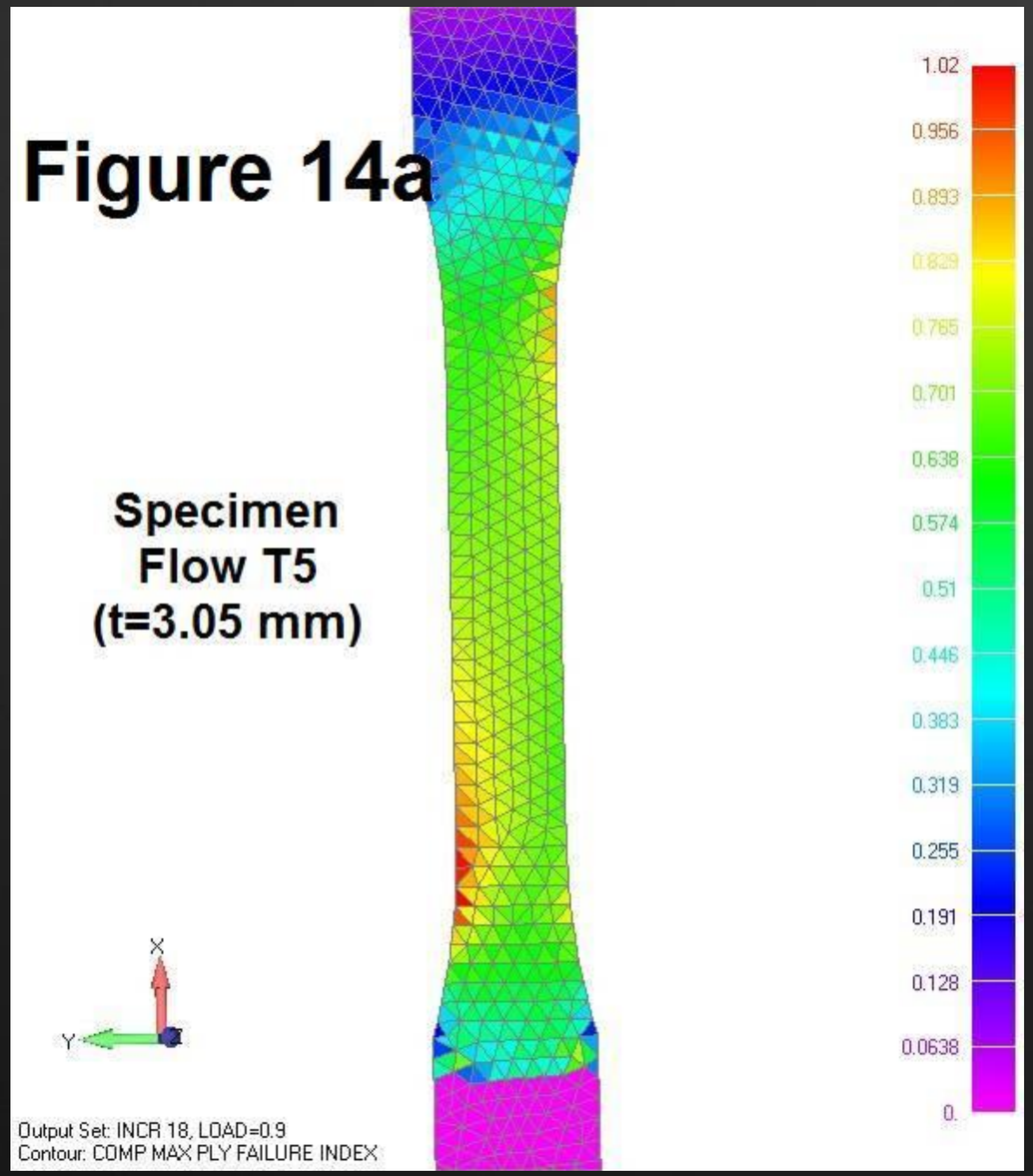
Figure 13

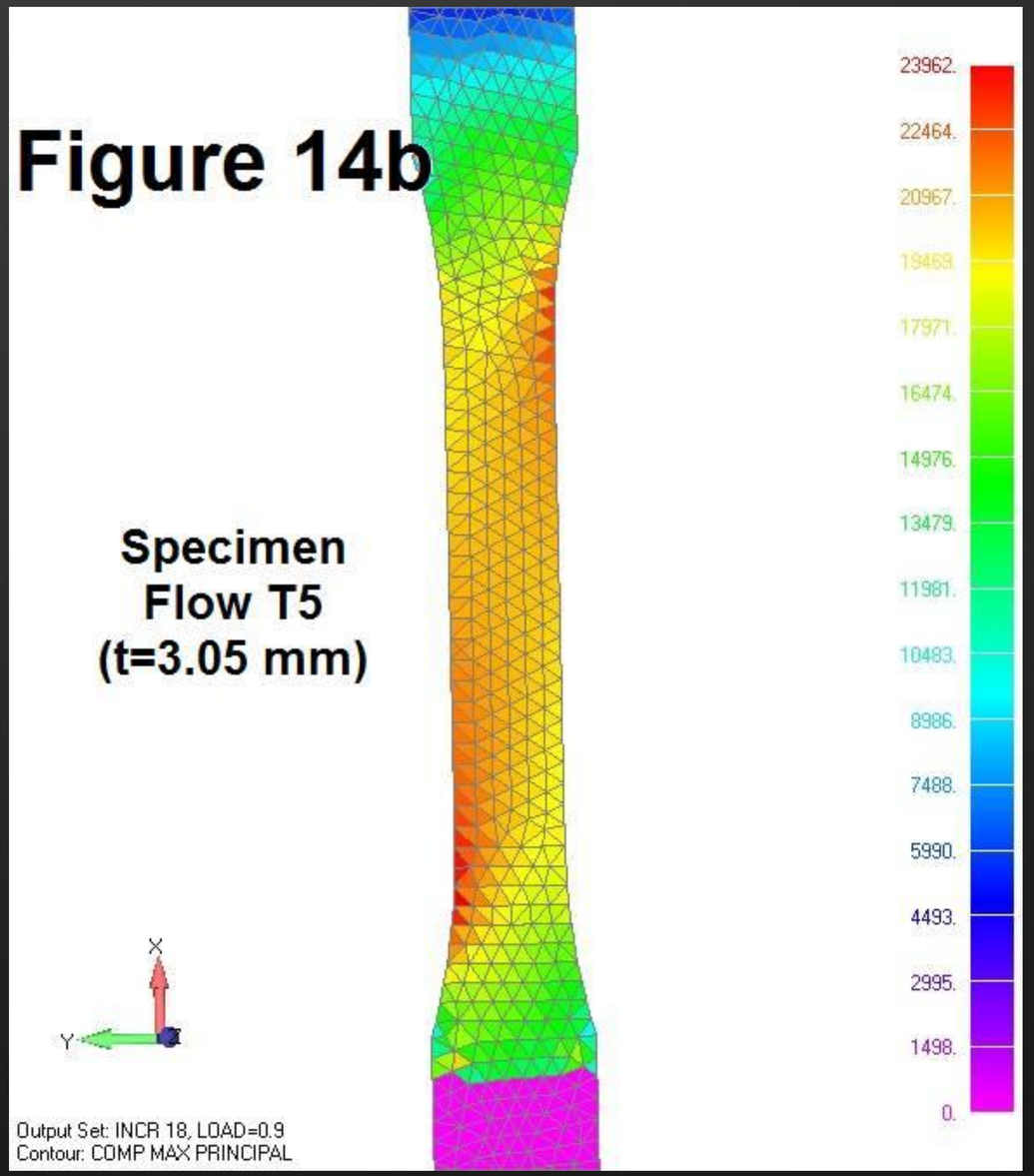
FIBSTRS API – Nanda Santhanam

Composite Lamina Stress Analysis – NEi NASTRAN®

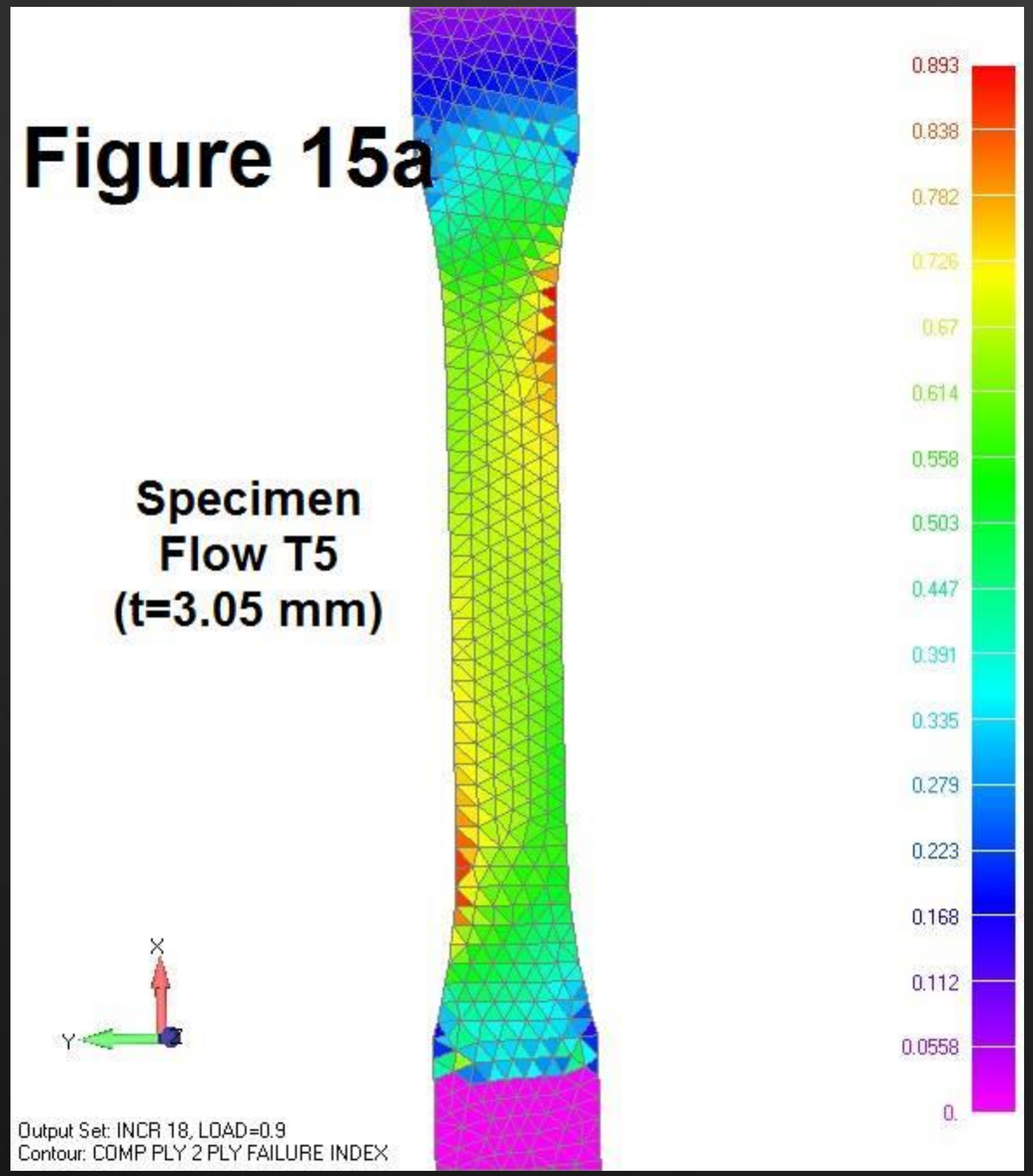
- Linear material model utilizes AMI modulus predictions
- Don’t rely on “back-calculated” resin properties
- Utilize low % secant modulus (0.5-1.0%)
- Delete panel geometry except tensile specimen of interest
- Apply testing boundary conditions and test load or displacement
- Add estimated strength allowables to material property cards
- Evaluate stress distributions and failure index based on different failure criteria

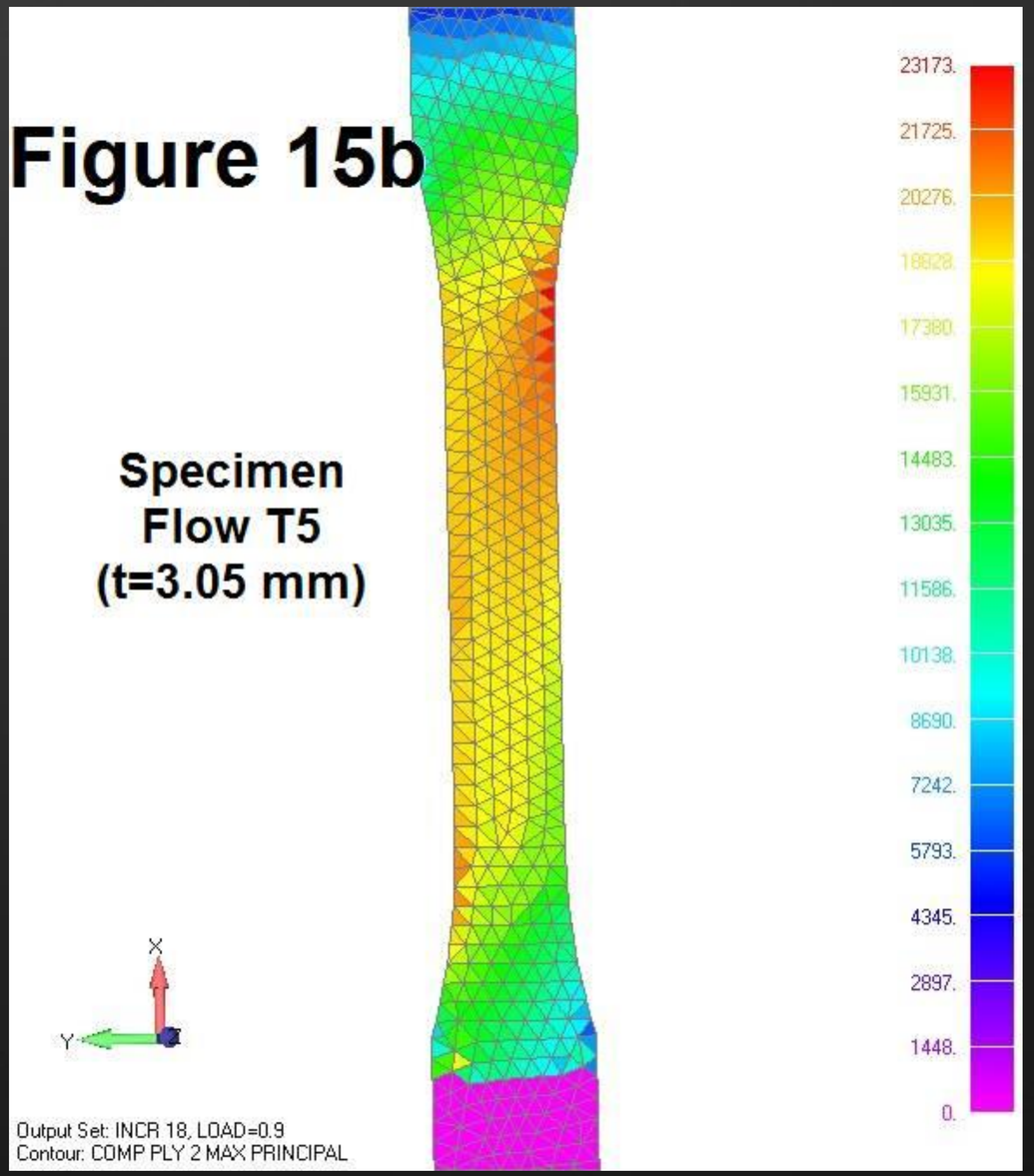
Stress Analysis – Flow Direction Specimen T5



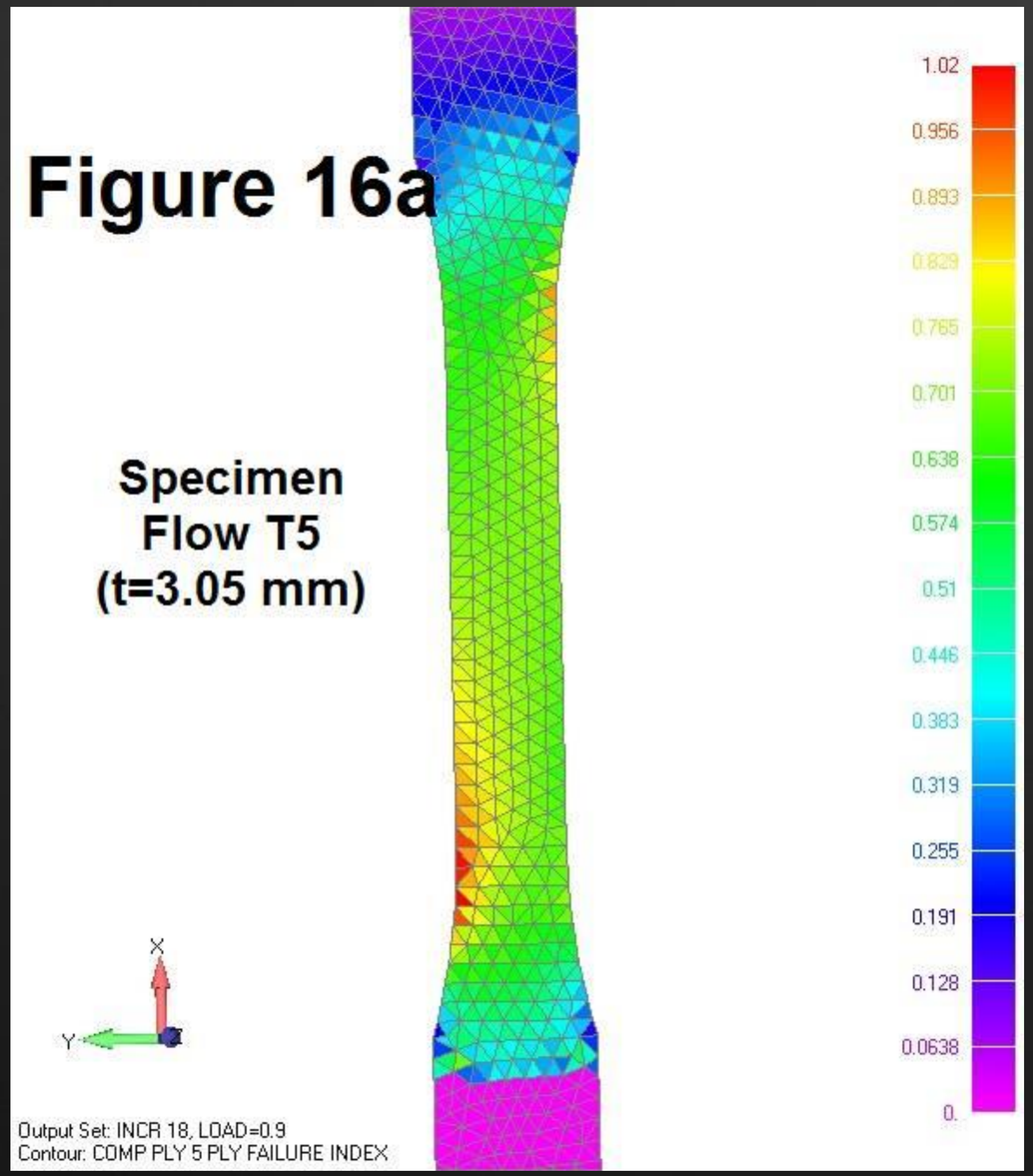


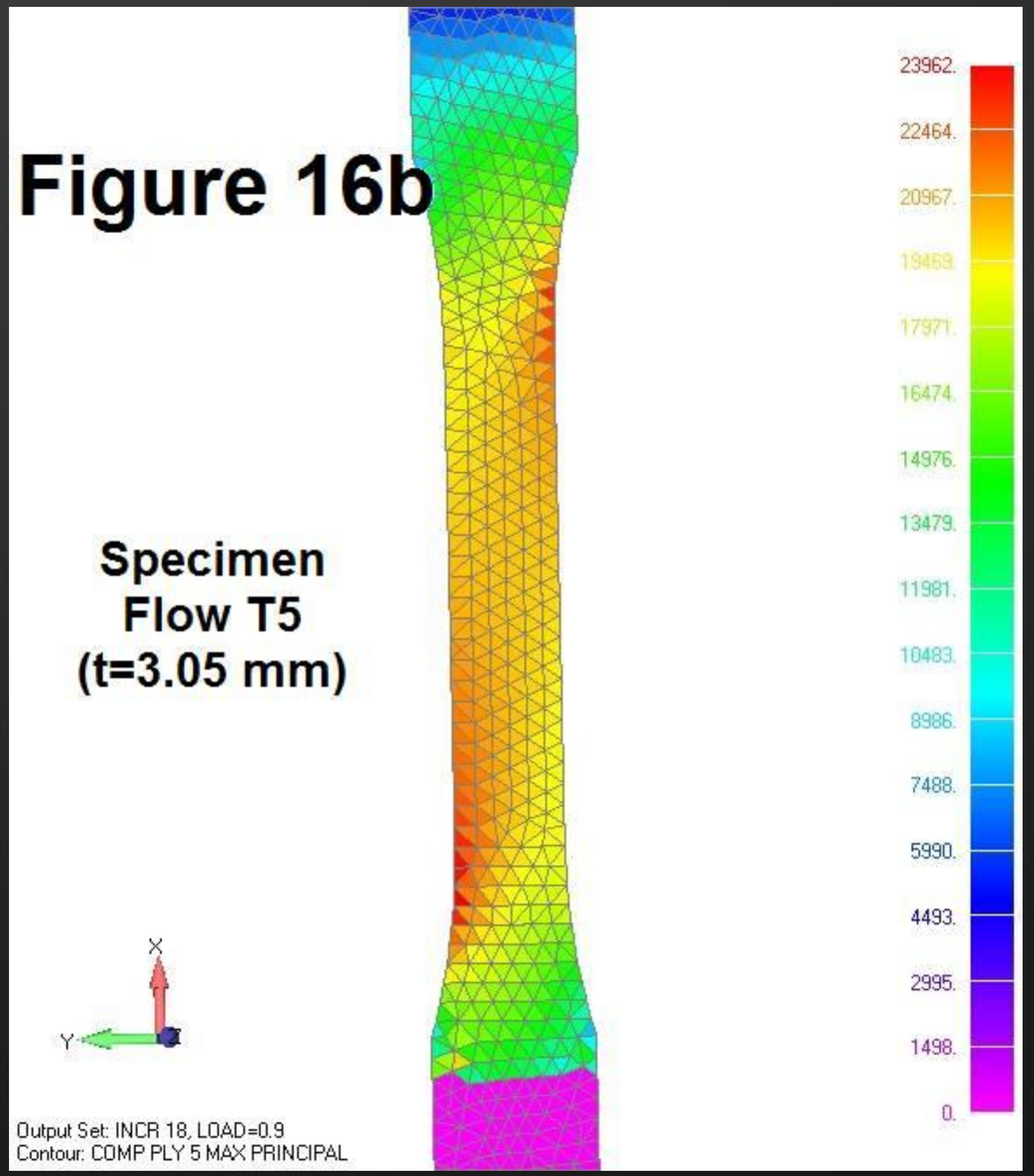
Stress Analysis – Flow Direction Specimen T5; Ply #2





Stress Analysis – Flow Direction Specimen T5;Ply #5





Summary

- Micro-mechanical property predictions can assist in orientation validation
- RSC factor has no “default” value
- Fiber AR may now be a useful variable with RSC implementation
- Composite lamina failure techniques can detect critical stress locations
- Implementation of “successive ply failure” and flexural simulation should help
- Much room for more research

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Questions?

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