

NEi Nastran MCT Ply Failure Analysis

Composite Analysis Tool for Optimal Design

MultiContinuum Theory

The traditional finite element approach to fiber reinforced composites is to smear the properties of the fiber and matrix together to arrive at a homogeneous representation of each layer. The smeared properties can be found from testing or a micro-mechanical approach. This “Black Aluminum” smeared approach provides limited information about exact failure mode and is known to be severely conservative for various loading scenarios.

The micromechanics-based MultiContinuum Theory (MCT) overcomes these limitations by separating the matrix and fiber properties, handling each composite constituent differently and allowing failure to progress through a multi-step damage mechanism. NEi Nastran now incorporates Firehole Technologies’ multiscale approach developed specifically for achieving optimal results with composite materials. After the FEA is run, exact failure mode can be obtained through accessing separate failure index calculations for fibers and epoxy matrices.

FEA Outputs

$$\epsilon_{composite}, \sigma_{composite}$$

$$\epsilon_{fiber}, \sigma_{fiber}$$

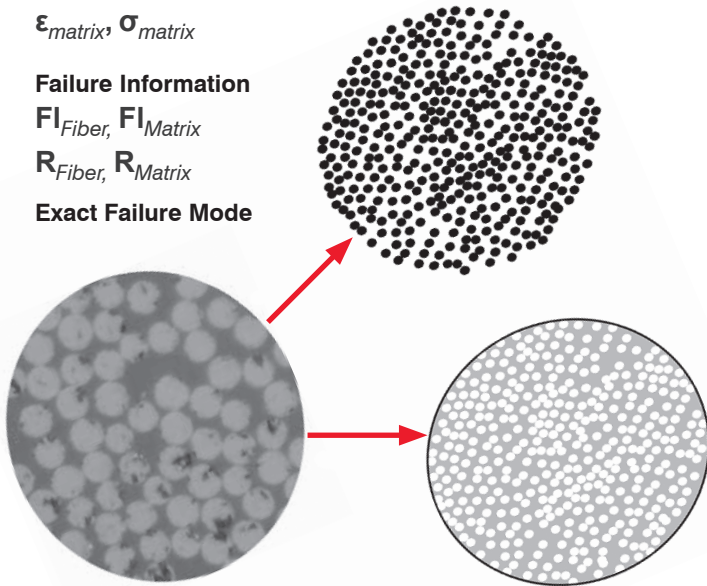
$$\epsilon_{matrix}, \sigma_{matrix}$$

Failure Information

$$FI_{Fiber}, FI_{Matrix}$$

$$R_{Fiber}, R_{Matrix}$$

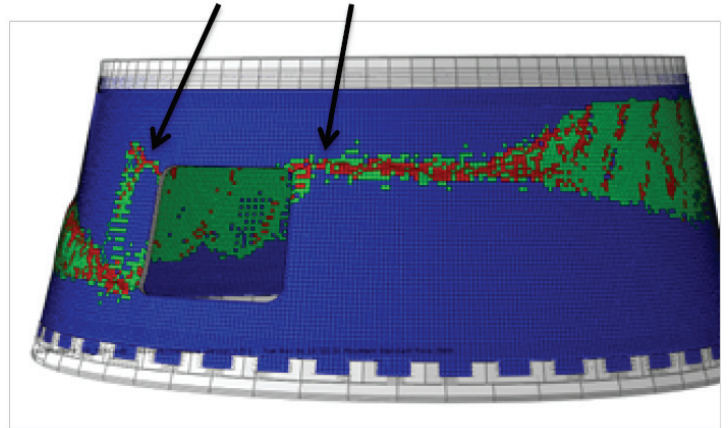
Exact Failure Mode



Using the MCT approach, failure criteria can now be applied at the fiber/matrix level. Stress and strain in the fiber and matrix are crucial when simulating composite response.

MCT Predicted Failure

Red = Fiber Failure Green = Matrix Failure



For this particular space composite adaptor, MCT predicted ultimate load within 2.5% of experimental ultimate load, whereas Tsai-Wu and other non-micromechanics based failure models were off by 30-75%.

What types of composites are MCT meant to analyze?

- Both unidirectional and woven composite materials
- High performance composites and polymers such as carbon fiber, glass fiber reinforced materials, and Kevlar
- Whisker-reinforced ceramic matrix composites (CMCs)

Benefits of NEi Nastran MCT

- Superior accuracy demonstrated through extensive validation ranging from coupon level, to simple laminates and full scale failure simulation
- Simple, easy to set up and use
- Requires only standard orthotropic material information
- Realistic FEA for composites, modeling at the constituent level
- Extremely computationally efficient
- MCT can be used with NEi Nastran’s Progressive Ply Failure Analysis (PPFA™) in advanced solutions such as nonlinear transient response and nonlinear static analysis to simulate micromechanics based damage degradation