GENOA Cheat Sheet

Overview of Capabilities and Features

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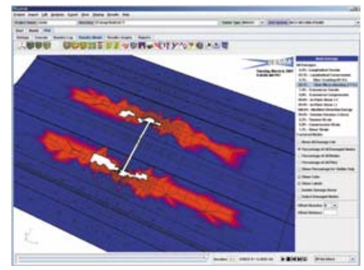
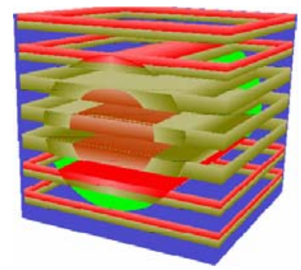
GENOA Virtual Testing Software for Durability, Reliability, Manufacturing, and Life Prediction

GENOA is an integrated structural analysis/design software suite developed to cost effectively predict strength, reliability and durability of structural components at the design stage with minimal experimental testing support. The software suite employs leading edge technologies from the fields of composites and structural science to deliver unequaled performance and analytical capability directly into the hands of today's design engineers. GENOA is a modular software dealing with linear and non-linear technology.

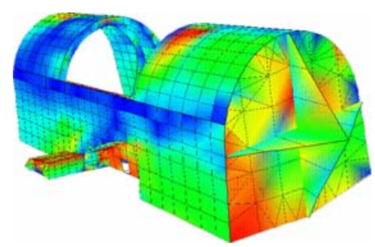
Durability Damage Tolerance (D&DT) by Progressive Failure Analysis (PFA)



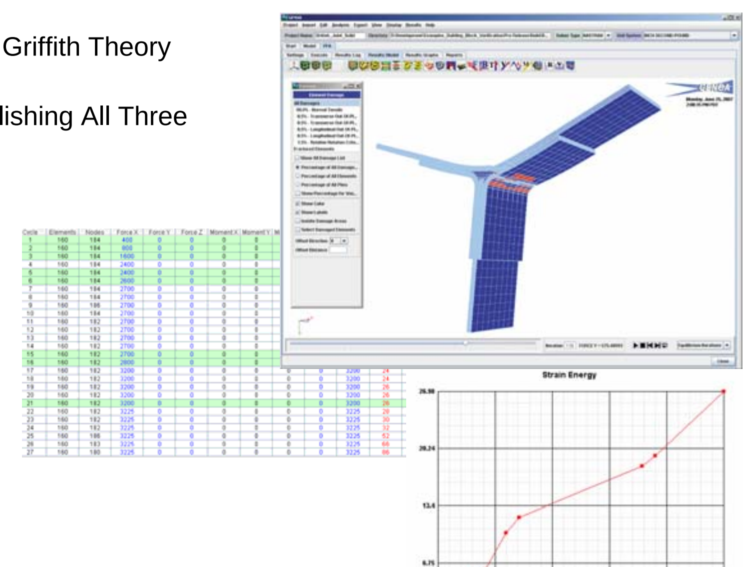
- **Static Thermo-Mechanical Loading**
  - Metal, Composites (Braid, Weave, Stitched 2D/3D), Honeycomb & Sandwich Structure
    - Static, Buckling, Post Buckling, Low Speed Impact (Static Indentation)
    - Advanced Damage Mechanics Failure Criteria (i.e. Delamination, Fiber Micro-Buckling, Fiber Crushing, & Interactive: SIFT & Puck, etc.)
- **Thermo-Mechanical Fatigue (TMF)**
  - Fatigue Low Cycle/High Cycle (Harmonic Loading), Random Fatigue, 2-Stage Fatigue, Creep
- **Progressive Failure Dynamic Analysis**
  - Low Speed Impact & High Speed Impact including Strain Rate Effect
- **Options:**
  - Probabilistic Design
  - PFA Optimization (**PFO**) – Maximize Durability
  - Virtual Crack Closure Technique (**VCCT**) and Discrete Cohesive Zone Model (**DCZM**)



Material Characterization Analysis



- **Composite Material Characterization**
  - Lamina and Laminate Thermo-mechanical Properties of 2D/3D Composites Including Weave and Braids.
  - Material Degradation, Crack Density and Residual Stiffness and Strength
  - A & B Basis Design Allowables
  - Effect of Variability of Manufacturing process (i.e. Void, Moisture) on Material Behavior
- **Metal Material Characterization**
  - Fracture Toughness Determination (FTD) by Extended Griffith Theory Based On Material Stress Strain Input.
  - Fatigue Crack Growth (FCG) Determines da/dN (Establishing All Three Regions) vs. Delta K Curves by Inputting FTD.
  - Strength-Life (S-N) Curve Prediction by Inputting FCG



Manufacturing Simulation Analysis

- Polymer Composite Filament Winding
- Preformed Composite
- Pultrusion Analysis
- Springback Effect

Software Specifications & Requirements

- NASTRAN, ABAQUS, ANSYS & LS-DYNA Solver Support
- Imports NASTRAN, ABAQUS & ANSYS models
- Windows 2000/XP or Linux (32-bit and AMD64) platform
- Java 1.5 & Java3D 1.3.1 minimum requirement
- 1 GB RAM recommended for analysis runs

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Progressive Failure Analysis Modules

PFA computes damage and fracture initiation and propagation loads. It relies on 18 failure criteria to evaluate material and structural damage at every load step. The code accounts for fiber breakage and fiber pullout, matrix delamination, degradation, and crack density. It relies on a building block verification approach that leads to: accurate prediction of failure loads and modes, reduction in the number of coupon and component tests, and acceleration of certification through virtual testing.

PFA – Quasi-Static (Low Cycle) is intended for the fatigue life prediction of composite and metal structures subject to static loads of constant amplitude.

PFA – Harmonic Fatigue (High Cycle) is intended for the fatigue life prediction of composite and metal structures subject to dynamic loads of constant amplitude.

PFA – Random Fatigue determines the fatigue life of composite or metal structures subject to a sequence of external cyclic excitations with variable amplitude and period.

Fatigue with Fracture Mechanics is designed for the fatigue life prediction of metal structures by combing the Progressive Failure Analysis-Virtual Crack Closure Technique (PFA-VCCT) and Fatigue Crack Growth (FCG).

PFA – Virtual Crack Closure Technique (VCCT) is fracture mechanics based approach for progressive crack growth analysis based on a linear spring assumption.

PFA – Discrete Cohesive Zone Model (DCZM) is 2D/3D fracture mechanics based approach for progressive crack growth analysis based on a bi-linear spring assumption.

PFA – Complex Unit Cell with Interface Modeling incorporates a slice-by-slice sub structuring technology from laminate to ply, to sub-ply, and then to fiber and matrix interface.

PFA – Honeycomb Sandwich Structure predicts damage initiation, growth and final failure in honeycomb structures. It assesses progressive failure due to shear crimping, flexural core crushing, face wrinkling and intracellular buckling.

Progressive Failure Dynamic Analysis (PFDA) evaluates structural damage resulting from high-speed impact events. It relies on explicit transient dynamic algorithm through the integration with LS-DYNA.

Composite and Metal Characterization Modules

Material Constituent Analysis (MCA) is a 2D/3D composites (i.e., Laminated, Woven, Braided, and Stitched) analyzer. It determines lamina and laminate thermo-mechanical properties, residual strength and stiffness, and simulates manufacturing process and environmental effects. This module evaluates effects of volume fraction, fiber packing, ply angles, void, moisture and curing on composite response. It is capable of distinguishing between "as designed" and "as built" composites.

Material Uncertainty Analysis (MUA) evaluates the effect of uncertainties in constituent (fiber and matrix) and fabrication process variables including defects properties on laminate structural behavior. It provides material A and B base allowables, cumulative and probability density functions (CDF and PDF), and sensitivities.

Material Characterization Optimization (MCO) reverse engineers ASTM coupon tests by establishing unified fiber/matrix properties to reproduce tests stress-strain fields. MCO is ideal for developing and validating material/testing standards by simulating experimental testing of composites.

Dedicated Material Database provides GENOA users with many fiber/matrix/lamina thermo-mechanical properties commonly used in aerospace and automotive industries.

Fracture Toughness Determination (FTD) incorporates fracture mechanics of ductile materials theory to calculate the fracture toughness (KIC). Its database contains dozens of stress-strain curves many grades of Aluminum, Titanium, Steel, Beryllium, and Inconel and nickel alloys.

Fatigue Crack Growth (FCG) determines the fatigue crack growth rate properties for ductile materials (da/dN versus ΔK) using input from various sources—including virtual testing done in GENOA/FTD module.

Manufacturing Simulation Modules

Filament Winding (FW) module is dedicated for the design and analysis of composite over-wrapped pressure vessels (COPVs). It converts the input winding schedule into composite laminates that can be analyzed further by PFA.

Chopped Fiber module is dedicated for the design and analysis of shredded fiber composites based on random angle distribution. Its benefits are: variable stiffness tow placement manufacturing techniques simulation, test reduction and increased modeling accuracy.

Reliability and Optimization Modules

Probabilistic Analysis (PA) determines the structural reliability under uncertain material, loading, service and manufacturing environments. The output includes the CDF, PDF, and sensitivities.

Progressive Failure Optimization (PFO) maximizes the structural performance of a composite structure by directing the design towards minimization of its service life damage.

GUI and Special Features

Graphic User Interface (GUI) is the central graphical user interface for all of the analysis modules. It includes 3D FEM graphics, standard modular interfaces, and reviewing for all of the analysis outputs. Multiple System of Units provides the GENOA users with the flexibility of choosing preferred unit system including SI and the capability of converting model and material properties from one system to the other.