MSC.Patran Laminate Modeler™

For the development of optimized laminated structures

OVERVIEW

MSC.Patran Laminate Modeler is an MSC.Patran 2003 Application Module to aid engineers in the design, analysis, and manufacture of laminated composite structures.

For the designer, Laminate Modeler provides an intuitive means for quickly specifying laminate designs that accurately reflect the ply-based physical composition of the structure.

Analysts benefit because Laminate Modeler helps improve the communication of structural details and the generation of the analysis model. This saves time, which can now be applied to the process of design verification and optimization.

For the manufacturer, Laminate Modeler highlights potential problems and provides accurate and complete manufacturing data, including the flat pattern shapes for each ply. This eliminates trial and error prototyping and minimizes material waste.

Integrate Design, Analysis, and Manufacturing

The composites development process requires tight integration between design, analysis and manufacturing disciplines from concept through manufacture.

MSC.Patran Laminate Modeler provides a common means of communication between designer, analyst and manufacturer. The laminate is defined in a manner that is acceptable to all parties. Ply properties, including fiber orientations and patterns, are stored in a single database. These data are readily exchanged with CAD-based composites tools during the development process.

PRODUCT LINE
MSC.Patran™

CAPABILITIES

• Calculate failure indices
• Optimize materials, plies, and layups
• Size zones efficiently
• Simulate manufacturability with robust draping algorithm
• Calculate and store fiber angle and shear data for every ply on every finite element
• Interface with multiple analysis tools
• Generate manufacturing data

BENEFITS

• Develop optimized laminated structures
• Enable collaboration between designer, analyst, and manufacturer
• Automate the Design Process
• Identify Problems Before Manufacture
• Integrated with MSC.Patran
• Share Composites Design Data with CAD
Size Zones Efficiently
The composites development process typically begins with zone sizing, often using formal optimization techniques needed to meet multiple constraints simultaneously. The Laminate Modeler provides integrated support for generating, evaluating and modifying MSC.Nastran™ SOL200 models where the thickness and orientation of individual laminate layers are varied. The user can merge individual laminate layers to consolidate zones with similar properties.

Identify Problems before Manufacture
Material shears and fiber angles change markedly when plies are draped over curved surfaces. Excessive shearing leads to manufacturing difficulties, while fibers may not lie in the required directions.

MSC.Patran Laminate Modeler incorporates extensive facilities to visualize plies, lay-ups and analysis models. Individual ply details can be reviewed immediately, while the stacking of plies at a point can be shown clearly through model or cross section plots.

Create and Interpret Analysis Models
Conventional composite analysis techniques use simplified zone approximations of the ply laminate. These models do not represent the detailed structure of the component, and are time-consuming to produce. Considerable skill is required to simplify models without affecting results.

MSC.Patran Laminate Modeler incorporates a robust draping algorithm to simulate productibility within seconds. If permissible levels of shear are exceeded, the user can reduce this by modifying the ply or inserting a dart. Identifying and dealing with manufacturing problems at the design stage saves great costs in downstream changes. Realistic material quantities can also be estimated early in the design process.

Visualize and Audit Models
Composite models are much more complicated than conventional ones. For example, a racing car monocoque is typically composed of several thousand plies. It is impossible to examine and track the use of these plies without specialized composites tools.

MSC.Patran Laminate Modeler calculates and stores fiber angle and shear data for every ply on every element of a finite element model. This is translated into a zone description required by the selected finite element code within seconds. This ensures that the analysis model closely resembles the design model. More importantly, any changes in the design model can be reanalyzed quickly. After analysis, the zone-based results can be sorted by ply to allow effective evaluation of structural response. For detailed analysis, shell elements can be extruded into equivalent solid elements where supported by the analysis code.

Support Multiple Analysis Codes
Composites development requires repeated analyses ranging from manufacturing simulation through to structural response under static, dynamic and crash loads.

MSC.Patran Laminate Modeler utilizes the power of the MSC.Patran simulation environment to generate input data for a wide variety of analysis codes. Layered results can be visualized and interrogated using sophisticated tools. These can even be used as input for subsequent analyses.
Calculate Failure Indices
Failure modes of composite structures are complex due to the anisotropic nature of the ply materials and the microstructure of the laminate.

MSC.Patran Laminate Modeler calculates failure indices using popular failure criteria including Maximum Stress, Tsai-Wu, Hill, Hoffman, Hankinson and Cowin methods. Users can also define custom failure criteria using PCL (Patran Command Language) functions. The failure analysis uses stress or strain results and material allowables stored in the MSC.Patran database. Margins of Safety, Failure Indices, critical ply number and critical load component are calculated for each element and can be visualized using standard tools. A text summary is also written.

Optimize Materials, Plies and Layups
MSC.Patran Laminate Modeler allows rapid modification of the design and analysis models during the development process. This allows the user to optimize a design comprehensively in the time previously required for a preliminary analysis.

Generate Manufacturing Data
Reflecting the complex structure of a composites model compared with a homogeneous component, a large amount of manufacturing data is required to construct a composite component.

MSC.Patran Laminate Modeler generates a sequential ply list and the 3D draped pattern and 2D flat pattern for each ply. This eliminates trial-and-error draping methods and variability resulting from laminator discretion. Mould surface data that accounts for fabric thickening on shearing is also produced. This avoids resin starvation during mould filling in RTM (Resin Transfer Molding) processes.

With MSC.Patran Laminate Modeler, real quality control can be designed into the manufacturing process. What was designed and analyzed is actually made, allowing a full audit trail for laminated composites.

Share Composites Data
MSC.Patran Laminate Modeler shares the composite design data between different tools used in the composites development process. Ply data can be exported to CAD-based tools for detailed design, and then imported back to allow for final certification analyses. This allows for enormous time savings compared with recreating the data manually in each environment.

Automate the Design Process
MSC.Patran Laminate Modeler is fully integrated within the MSC.Patran analysis environment and it is fully programmable using PCL (Patran Command Language). This means that the design and analysis process can be automated for families of components. This leads to the generation of more consistent designs in a fraction of the time normally taken.
MSC Patran Laminate Modeler is widely used in many different industries. Sample user scenarios and particular benefits are presented here.

**Aerospace: Wheel Cover**
The wheel cover is a typical aerospace component made from over one hundred plies. The plies are defined in the CAD system and transferred automatically to MSC Patran Laminate Modeler for analysis.

Creating an accurate, ply-based analysis model now takes minutes. This is two orders of magnitude faster than the elapsed time required to develop a simplified model manually. Verification and failure analysis tools aid subsequent analysis.

**Motorsport: F1 Monocoque**
The monocoques of Formula 1 cars are typically composed of over two thousand plies. The analysis model usually contains over one hundred thousand finite elements due to the complexity of the structure. Models are developed within a two-week timeframe, and are compared with test.

With MSC Patran Laminate Modeler, users can develop an accurate ply-based model and optimize it in less than the time taken to generate a simplified model using zones in the past. Critical regions can be identified quickly using the failure analysis capabilities. Both linear and crash analyses can be generated from the same composites model.

**Automotive: Floorpan**
Automotive use requires quicker and cheaper fabrication, which is met using larger, thicker plies. This means that shear buildup and resulting manufacturing difficulties are critical.

With MSC Patran Laminate Modeler, it is possible to predict productivity of a ply within seconds. In addition, the effect of shear on fabric properties on stiffness and strength can be accounted for in the analysis.

**Marine: Yacht Hull**
Modern high-performance racing yachts sport large ballast ratios and light structures, sometimes leading to spectacular failure.

With MSC Patran Laminate Modeler, it is possible to build an accurate ply-based model of the structure in an automated way using PCL (Patran Command Language). Failure analysis can be undertaken for multiple load cases. Ply books and manufacturing data are produced to ensure that the analyzed model is built.

**Energy: Wind Turbine Blade**
Wind turbine blades approaching forty meters in length are being produced using composite materials. The structure must be analyzed for flutter and local buckling. The most critical constraint is cost.

With MSC Patran Laminate Modeler’s unmatched capability to modify materials, plies and lay-ups rapidly, it is possible to compare the performance of different solutions to minimize cost. Multiple analyses using different codes can be run using a single composite model. Manufacturing data are produced to ensure that the analyzed model matches the final component.
Leisure: Helmet
New helmet designs incorporating fiber reinforcement are being produced for sport and leisure activities. These have superior performance but cost must be reduced.

With MSC.Patran Laminate Modeler, it is possible to predict the amount of shear developed in a ply. This allows the development of manufacturing strategies to reduce manufacturing variability and cost. Subsequent analyses can also account for material shear. Finally, manufacturing tooling can be machined to account for fabric thickening during forming.

SELECTED FEATURES
Sizing Model Definition
- Supports MSC.Nastran™ SOL200 sizing
  - Expand laminates
  - Create Design Variables for layer thickness and orientation
  - Verify updated values
  - Modify laminate layers
  - Compress laminates

Layup Surface Definition
- Specify lay-up surface
  - Imported CAD model
  - Created in MSC.Patran
- Define finite element model
  - QUAD4/8, TRI3/6 shells
- Import mesh from Layup file
- Verify mesh topology
  - Branches
  - Normal Boundaries
  - Connectivities
  - Feature Angles
  - Material Orientations

Material Specification
- Define manufacturing characteristics
  - Initial thickness
  - Initial warp/weft angle
  - Maximum shear
- Associate analysis material
  - Specified by user
  - Imported via MSC.Patran Materials
- Modify rapidly

Ply Specification
- Select appropriate application method
  - Painting (coatings or foams)
  - Projection
  - Draping (fabrics)
- Select flexible projection options
  - Arbitrary vector.
  - Arbitrary plane.
  - Element datum.
- Select flexible draping options
  - Woven or Unidirectional materials
  - Principal Axes: None, Geodesic, Planar
  - Extension Type: Geodesic, Energy, Maximum
  - Darts
  - Limit 2D Fabric Size
  - Specific order of draping
- Modify rapidly
  - Recreate ply definition
  - Change application method
  - Identify and fill holes in imported plies
  - Edit ply coverage
- Import plies from external Layup files and MSC.Nastran input files

Layout Specification
- Add/Insert/Replace/Show/Delete plies
  - Define multiple ply instances
  - Define angular offsets
- Define laminate offsets
  - Multiple areas
  - Top, Middle or Bottom offset
  - Arbitrary value
- Modify rapidly
  - Mirror about arbitrary plane
  - Use multiple lay-ups in a model

Analysis Model Creation
- Generate analysis models for a wide variety of analysis codes, including:
  - MSC.Nastran™, MSC.Marc™, MSC.Dytran™
  - ABAQUS®
  - ANSYS®
  - SAMCEF
  - LS/DYNA3D
  - Pamcrash
- Select appropriate element types supported by analysis code.
- Select laminate orientation for analysis code.
  - Element edge
  - Coordinate system
  - Vector
- Define orientations by field.
- Define area for model generation.
- Minimize data within a user-defined tolerance.
- Tighten tolerance in critical regions.
- Reference sheared material properties.
- Ignore thickening for preliminary analysis.
- Choose equally spaced thickness and orientation variables.
- Preview number of laminate materials, properties and coordinate systems for required tolerance.
Solid Model Creation
- Extrude shell elements through laminate thickness to generate solid elements
- Create analysis data for selected analysis codes
  - Orientation systems
  - Equivalent anisotropic materials
  - 3D laminates where supported

Visualization
- Verify plies
  - Material
  - Application direction
  - Reference direction
  - Selected area
  - Maximum Strain
  - Warp and weft angles on each element
  - 3D laminates where supported
- Create analysis data for selected analysis codes
  - Orientation systems
  - Equivalent anisotropic materials
  - 3D laminates where supported
- Verify layups
  - Orientation and separation of surface plies
  - Laminate surface
  - Stacking sequence on element
  - Cross section through arbitrary plane
  - Exploded ply view
- Verify analysis model
  - Properties and laminates for elements
  - Layer material by scalar plot
  - Layer orientation by vector plot or XY plot
  - Layer thickness by model plot, scalar plot and XY plot

Failure Calculation
- Use layered stress or strain results
- Select required criterion
  - Maximum
  - Tsai-Wu
  - Hill
  - Hoffman
  - Hankinson
  - Cowin
  - User-defined using PCL
- Define Allowables
  - Use standard values
  - Account for degradation
- Select required results
  - Use standard values
  - Account for degradation
- Select required results
  - Margin of Safety
  - Critical Layer
  - Critical Component
  - Failure Index (equivalent to MSC.Nastran)
- Layer-by-Layer results
  - Text summary

Access Results
- Read results from MSC.Nastran .f06 files

Results Sorting
- Sort result layers on the basis of
  - Plies
  - Analysis material id

Manufacturing Data Creation
- Create ply book for one or more plies in lay-up
  - Text ply index
  - Images of plies on model
- Export 3-D draped pattern shape for selected plies in IGES, DXF
- Export 2-D flat pattern shape for selected plies in IGES, DXF
- Export Mould Surfaces in IGES

Data Sharing
- Share data with CAD-based composites tools
  - Import ply coverage, start point, application direction, warp/weft angles, thickness
  - Export ply boundaries, start point, application direction, fiber paths
- Share data with laminate analysis tools
  - Import materials and laminate materials
  - Export materials, laminate materials and loads

Process Automation
- Fully customizable using PCL (Patran Command Language)