Composites modeling with ANSYS

Modeling Layered Composites the Simple Way

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Motivation

Composites offer tremendous weight savings, increased performance, and design flexibility.

The composites market is a relatively young, fast growing and technologically evolving market.
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The composites market is a relatively young, fast growing and technologically evolving market.
Levels of Analysis

fiber–matrix–level

matrix

heterogeneous layer

fiber

interface

goal: FEM—simulation of shell–like structures

structural–level

layer–level

layered cross section

homogenised layers

orthotropic / transversely isotropic material behaviour

laminated cross section
Multiple materials, complex layups, large number of plies etc. makes the job difficult to design parts with these materials.

Compared to homogenous materials like steel or plastic, composites are much more challenging to analyze.
“The intuitive implementation of composite design development in ANSYS Composite PrepPost brought out a revolution in composite simulations. We are able to realize a continuous design process from simulation results to manufacturing including design modifications within the development.“

Hendrik Mester, Rotor Blade Development, REpower Systems AG
Shell based composites
Motivation

ANSYS Workbench provides superior CAD connectivity, meshing and an easy framework to perform design optimization.

With R14.0, we greatly improve the workflow for analysis of composite components.
Engineering Data Enhancements

New in R14

New at Release 14.0

→ Orthotropic stress/strain strength properties

→ Tsai-Wu, Puck, LaRc03/04 Constants

→ Properties available to ACP and Mechanical and MAPDL
Manually Defining Layers on Simple Geometries

Users can define simple layered sections for a shell body as well as define thicknesses and angles as parameters.
Basic Layer Definition in Mechanical

New in R14

Layered Section Object

Allows a user to define simple layered section for a shell body

Inserted under the Geometry folder from the toolbar or its RMB insert menu
Layered Section Object

Details

Scope to bodies or faces
Options to define offset and sequencing
Graphics option to display specific layer to help verify correct offset, sequence, etc.
Worksheet View to enter layer data

Thickness, angle values can be parameterized
Layered Section Object Example

Graphics: Section Thickness, Location
Postprocessing

Layer Control, Membrane/Bending Output

New Membrane-Bending stress results.

Ability to choose which layer to view results.
Explicit Composite Example

New in R14

CFRP Baseball bat with spiral CRFP reinforcement

Layered Section

<table>
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<tr>
<th>Layer</th>
<th>Material</th>
<th>Thickness (m)</th>
<th>Angle (°)</th>
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<td>6</td>
<td>CFRP-Uni</td>
<td>0.0002</td>
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</tr>
</tbody>
</table>

Normal Stress in 3rd Ply, 45° to Bat Axis
Defining Layers on Complex Geometries

For complex geometries, the ANSYS Composite PrepPost tool is used and layer definitions are imported in the assembly model in ANSYS Mechanical.

Courtesy of TU Chemnitz and GHOST Bikes GmbH
Data Integrated ACP with WB

**New in R14**

- ACP introduced as a component system inside WB
- Like a typical WB system, file management and standard actions like Update, Duplicate
- Consume materials from Engineering Data
ACP-Mechanical Linkage

New in R14

→ ACP Pre system contains EDA, Geometry, Model and Setup (same as ‘Mechanical’ system)
→ Setup cell launches ACP Editor
→ Mesh (shell) is transferred from Mechanical into ACP
→ ACP then passes, discrete section data to Mechanical as ‘Imported Layered Section’ object
ACP-Mechanical: Example Schematic

New in R14

Explicit (Autodyne)  Implicit (MAPDL)

Parameter Support

Include as part of Design Exploration
You can define additional composite layers using the concept of fabrics, stackups and sub-laminates.
Complex Curved Structures

A system of rosette combination can be used to Define material reference directions
For structures with high curvatures etc. Manufacturability is a big factor in design

ACP can predict draping, fiber angle correction etc.
Verify model setup by viewing the stacking sequences or by generating a Ply-book.
Asymmetric Laminates

ACP allows multi-orientations of the same region to support asymmetric laminate definition
State of the art post-processing
Identify critical parts by highlighting failure mode, failed layer and critical load case in one plot
Miscellaneous Enhancements

New in R14

VCCT

→ In R14, ACP you can define a modeling-ply as a VCCT layer. When the solid-model is generated a VCCT layer is introduced between the corresponding plies.

Performance

→ In R14, ACP now groups elements with similar or identical section-definition (based on limit-angle and thickness). For most models this results in a drastic reduction of section-data which helps improve solver performance
Solid composites models
Use CAD data to create cut-off rules

CAD data can be used to extrude plies from surface to SOLID mesh to model complex 3D shapes
Solid Extrusion

Varying core thickness applied by tables or 3D CAD model
Auto Detect Butt-Joined Ply Boundaries

*New in R14*

In R13 ACP creates drop-off elements on all ply boundaries.

With R14 ACP will now automatically collect non-overlapping plies and extrude them in one group in order to create smooth transition zones in between of them.
Multi-Component Mesh extrusion

*New in R14*

In R14 ACP will detect free shared edges and automatically eliminate internal free edge ends to enable a fully automatic solid extrusion of a more general class of shell meshes.

Two-component tube assembly with two free shared edges

Three virtual components (R14)

Solid extrusion in ACP 14 (illustration without butt-joined plies)
Partner-ESACOMP

**Concept**
- Design Concept
- Material Selection
- Preliminary Lay-up Design

**ESACOMP**
- Laminate analyses: Solid laminate / Sandwich
- Analyses involving geometry: Panel (flat, stiffened, curved), Beams, Joints, Notches
- Material Data Bank
- Multiple failure criteria
- Polar plots, Layer charts
- ESACOMP/ANSYS ACP Interface
Partner-ESAComp

- ESAComp
- ANSYS Design Modeler
- ANSYS Space Claim Direct Modeler
- ANSYS & ANSYS WB
- ANSYS Composite PrepPost
Interact with Vistagy’s FiberSIM for manufacturing details
Composites Modeling with ANSYS Solutions