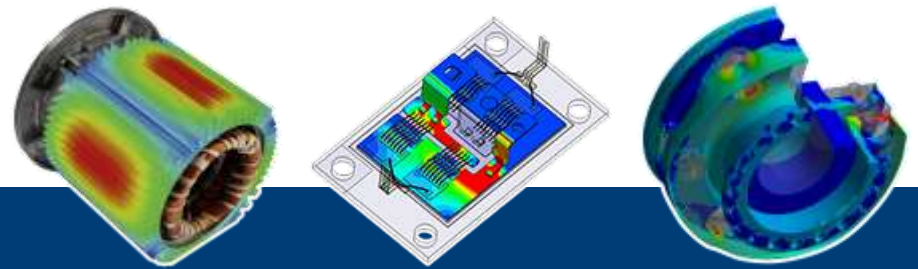


Simulation ist mehr als Software®



3. Fachkongress Composite Simulation

20. März 2014, Schwabenlandhalle Fellbach

CADFEM

Shell-based Composite Analysis

Solid Composite Analysis

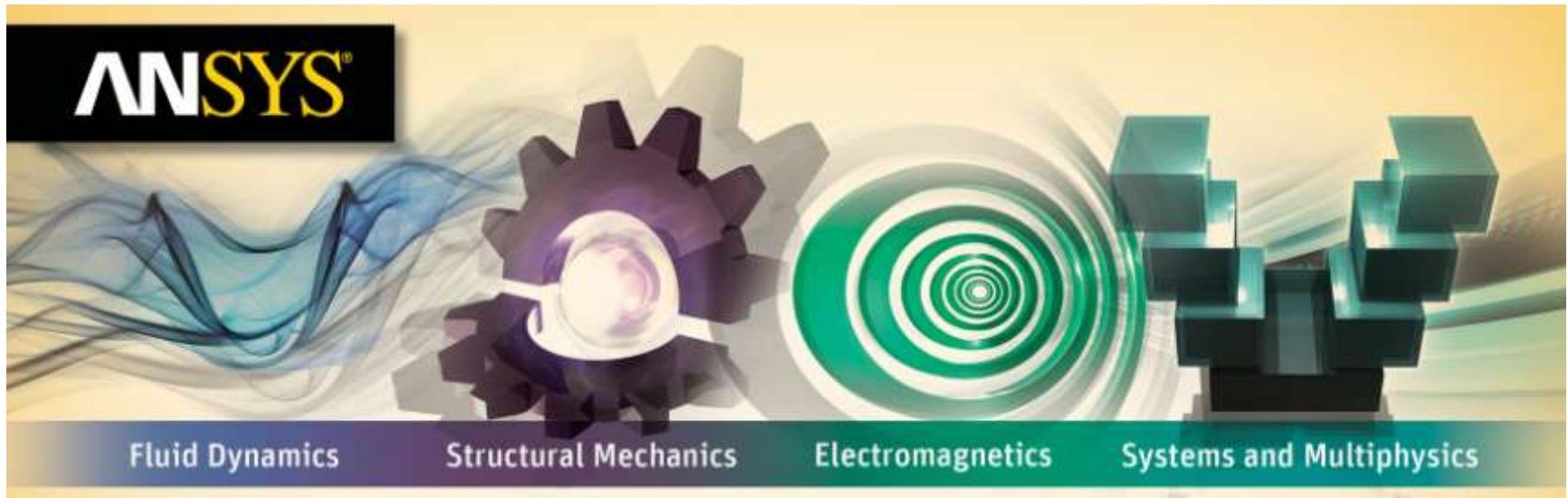
Additional Features

Preview Composites Simulation

Simulation macht vieles möglich

- Wegweisende Innovationen entwickeln
- Maßstäbe in der Produktqualität setzen
- Kosten und Entwicklungszeiten reduzieren

PRODUKTE – Software und IT-Lösungen



PRODUKTE – Software und IT-Lösungen

- eCADFEM – Software as a Service
 - Software mieten: so oft und lang wie nötig
 - Flexibler Zugriff auf Lizenzen
 - Maximale Datensicherheit
 - bereits 1.300 Kunden
- CAE-optimierte IT-Infrastruktur
 - Workstations, Server und Cloud
 - einsatzfertig: installiert, vorkonfiguriert und getestet
 - effizientes Arbeiten mit optimierter Hardware (z.B. HPC)
 - Service Level Agreement



SERVICE – Beratung, Support, Engineering

- Ihr Einstieg in die Simulation leicht gemacht
 - Bewährte Konzepte für die Einführung der Simulation ohne Risiko

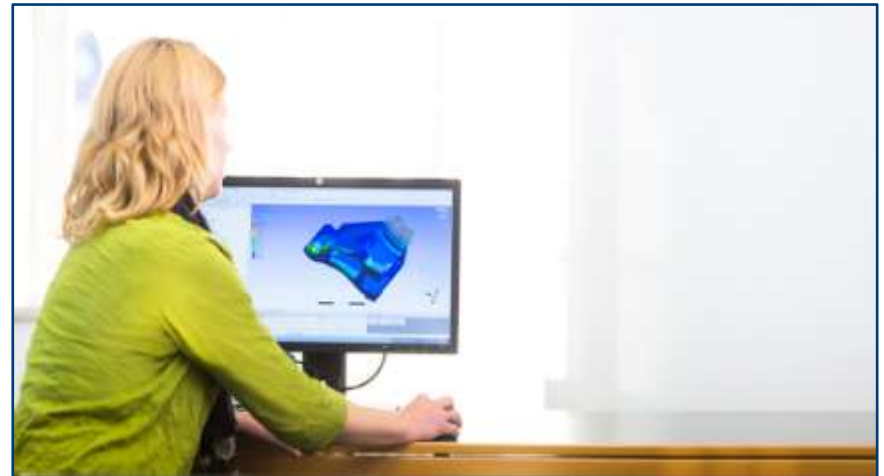
- Anwendersupport
 - 30 CADFEM Ingenieure helfen bei der Anwendung der Software
 - Support auch bevor das Projekt beginnt
 - Zweitmeinung einholen
 - Vertrauen in die Simulationsergebnisse



SERVICE – Beratung, Support, Engineering

- Simulation im Auftrag
 - Entwicklungsbegleitend, bei Engpässen oder für bestimmte Expertise
 - Nachweise nach Industrienormen
 - Lieferung der Ergebnisse, Lösungswege und Berechnungsmodelle

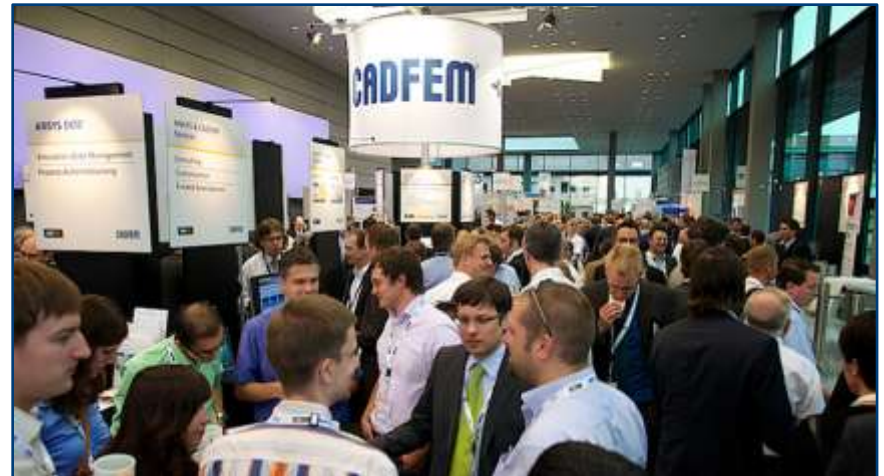
- Softwareanpassung
 - Template-Programmierung
 - reproduzierbare Workflows
 - Beschleunigung der Modellerstellung
 - Qualitätssicherung der Simulationsprozesse
 - Programmierung von Zusatzlösungen



Simulation einer Schaltanlage; um 90% verkürzte Bearbeitungszeit. Quelle: Siemens AG

WISSEN – Know-how-Transfer

- CADFEM Users' Meeting
 - Treffpunkt von 800 CAE-Anwendern seit 30 Jahren
 - Die Plattform für den Erfahrungsaustausch
- Software-Seminare zu 50 CAE-Themen
 - Softwarebedienung UND Engineering
 - 5.000 Teilnehmertage im Jahr
- Fachmedien
 - CADFEM Journal (35.000, 2xjährlich)
 - Fachbücher
 - www.CAE-Wiki.com
 - www.youtube.com/cadfem



CADFEM – CAE-Simulation seit 1985

- CADFEM in D, A, CH
 - 1985 gegründet
 - 12 Standorte
 - 185 Mitarbeiter
 - 60 Millionen Euro Umsatz
 - 2.300 Kunden
- CADFEM worldwide >250 Mitarbeiter
- ANSYS Competence Center FEM in Zentraleuropa
- Teamwork mit ANSYS Germany, ANSYS Competence Center CFD



Competence Center FEM

CADFEM

Shell-based Composite Analysis

Summary

Solid Composite Analysis

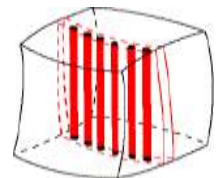
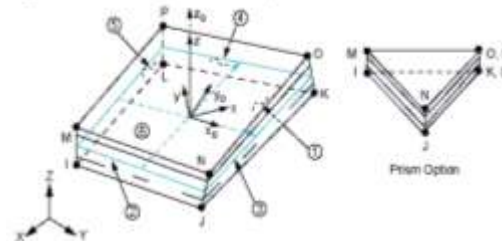
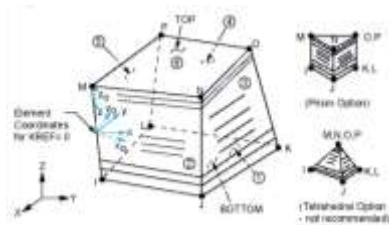
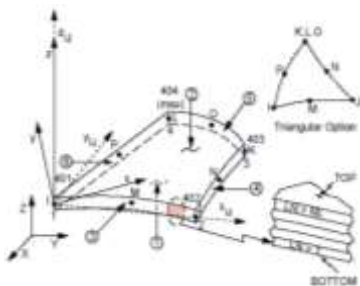
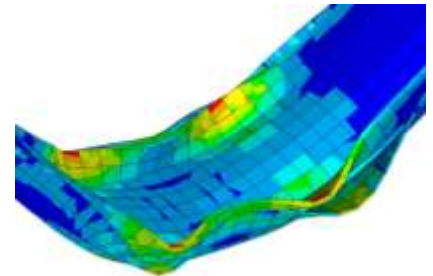
Changelog ACP R14.5.7

Preview Composites R15.0

Shell-based Composite Analysis

ANSYS and Composites

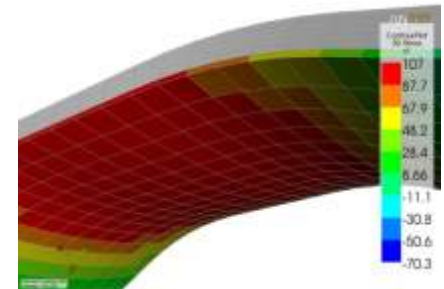
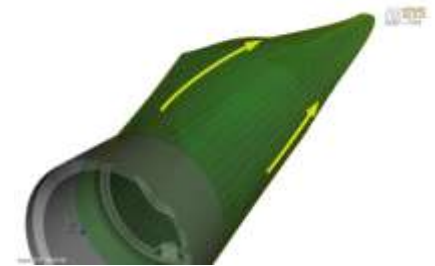
- ANSYS is not new to composite simulations.
 - Layered shell and solid elements for more than two decades.
 - Rich variety of elements for composite modeling from 1D to 3D.



Shell-based Composite Analysis

What can I do with ANSYS Composite PrepPost?

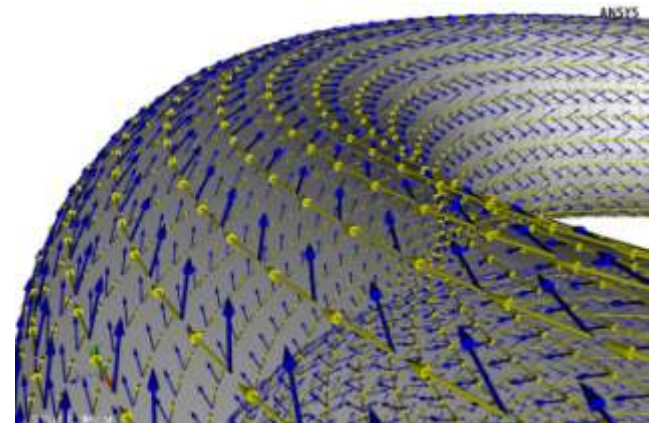
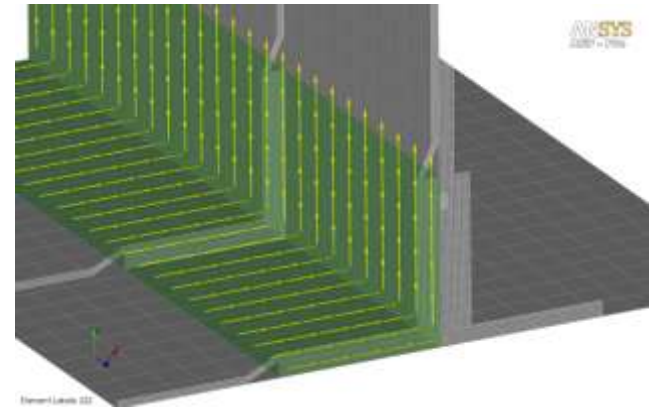
- Build up your Composite Design
 - Define the composite layup
 - Define fiber directions
- Evaluate your Composite Design
 - Evaluate stresses in the layers
 - Evaluate failure criteria



Shell-based Composite Analysis

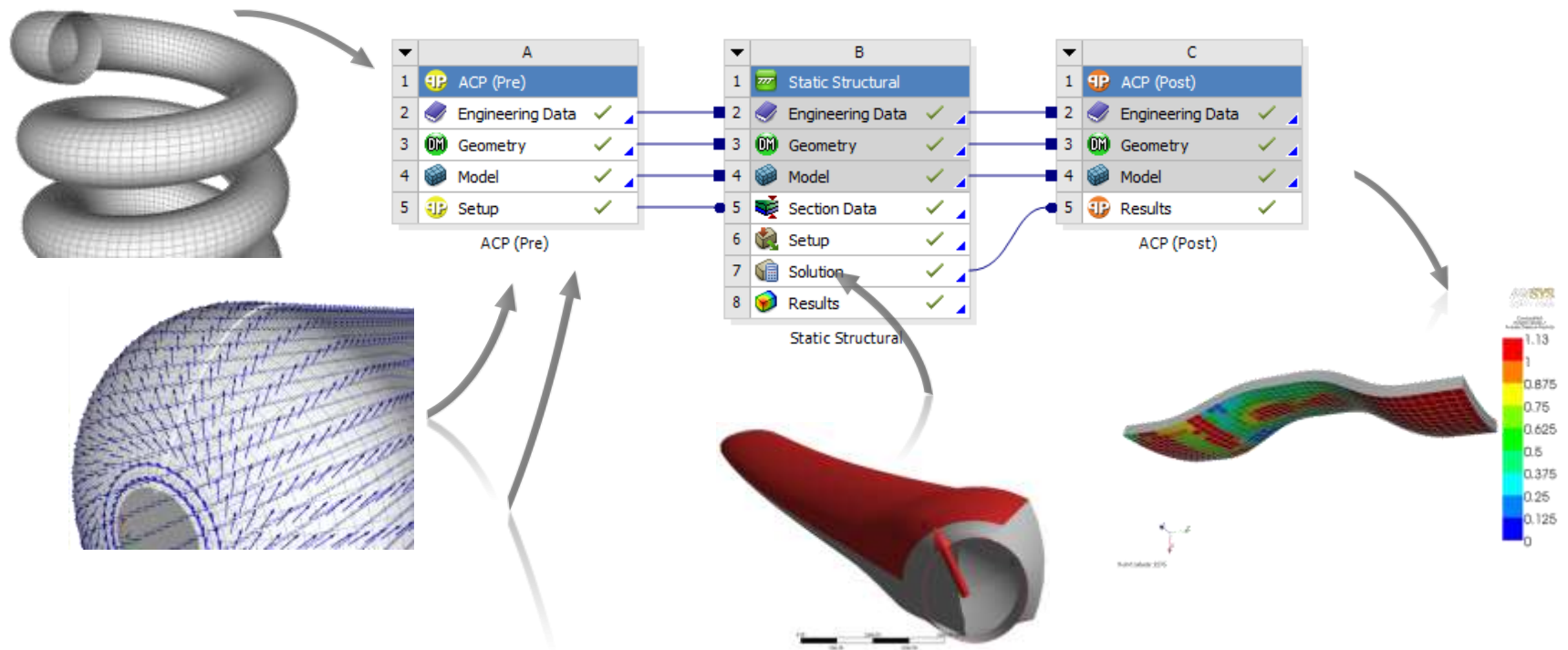
ANSYS Composite PrepPost is the Next Step

- Intuitive workflow for composite modeling.
- Different options to define fiber orientations.
- Quick setup of composite layup.
- Quick postprocessing.
- Allows design studies of different composite designs.



Shell-based Composite Analysis

The Workflow in ANSYS Workbench



Shell-based Composite Analysis

CAD model
enhancement

Model
preparation

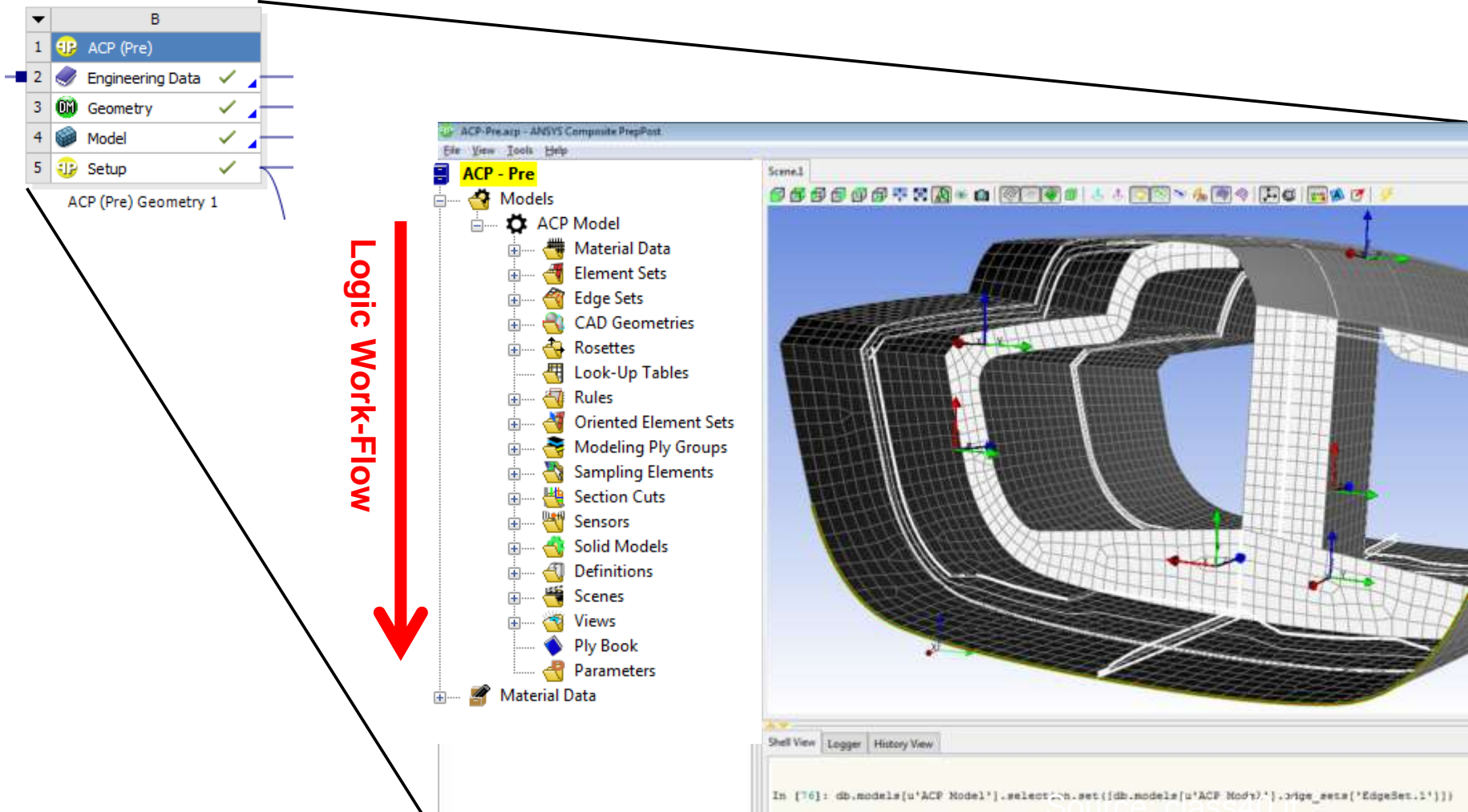
Design Loops
& Tools

Design
improvement

Composite
postprocessing

Composite
preprocessing

Shell-based Composite Analysis



Shell-based Composite Analysis

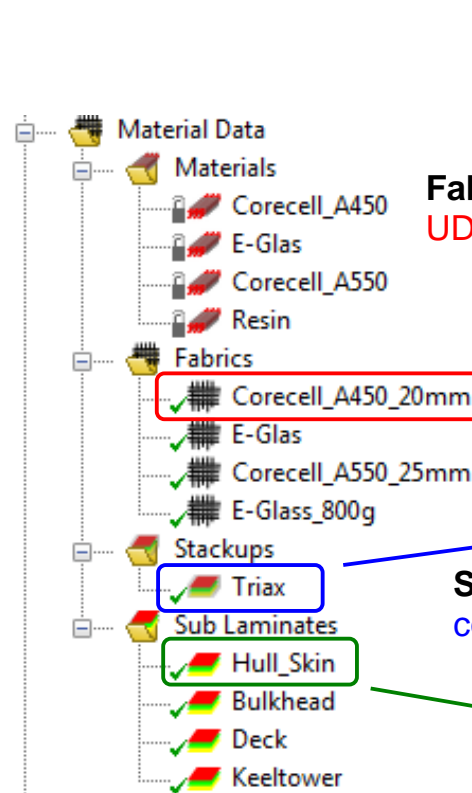
Typical **Fabric**:
Carbon UD



Typical **Stackup**:
Non-crimped
fabric



Material Level



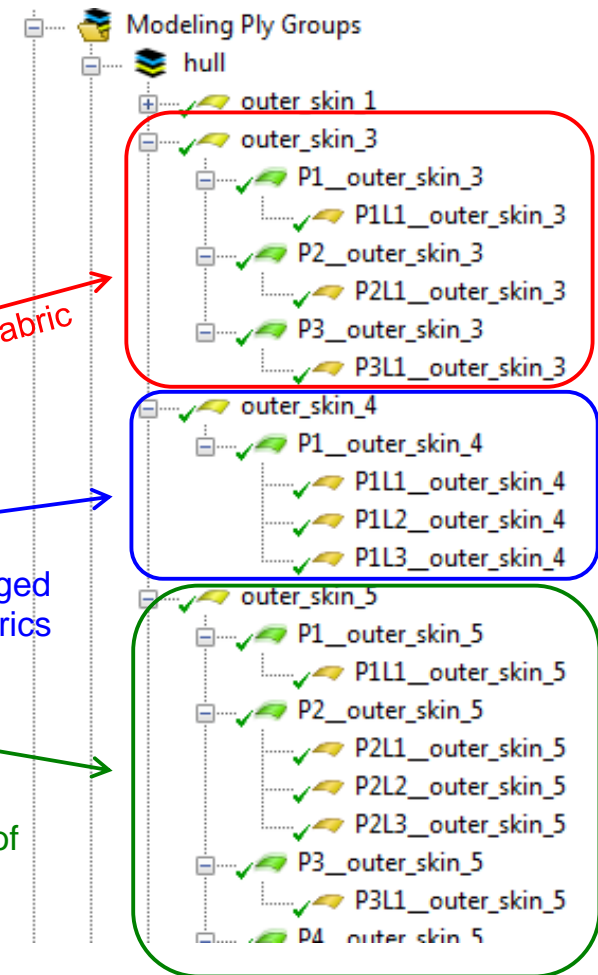
Fabric Single ply,
UD or Woven

3-times same fabric

Stackup Prearranged
combination of fabrics

Sub Laminate Collection of
fabrics or stackups

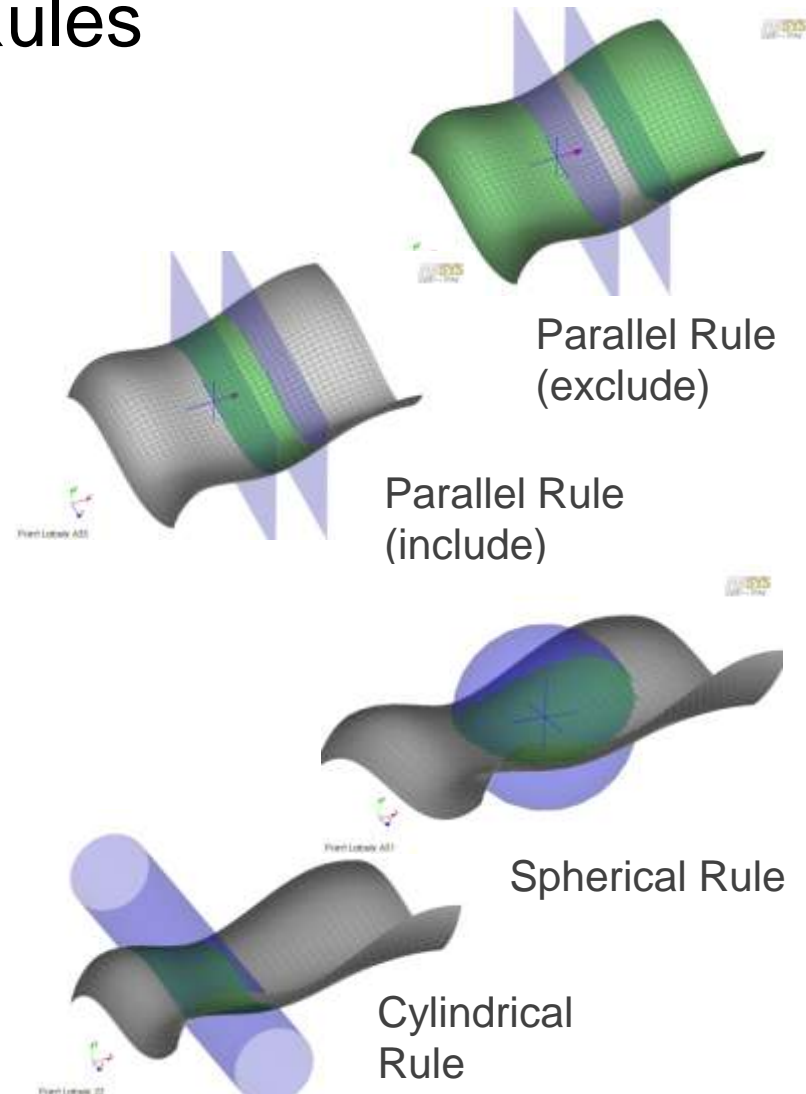
Ply Level



Shell-based Composite Analysis

Layup Surfaces defined by Rules

- Rules can be used as include or exclude rule.
- A parallel rule selects all elements between two locations.
- Cylindrical or spherical rules are used to reselect elements within a cylinder or sphere.

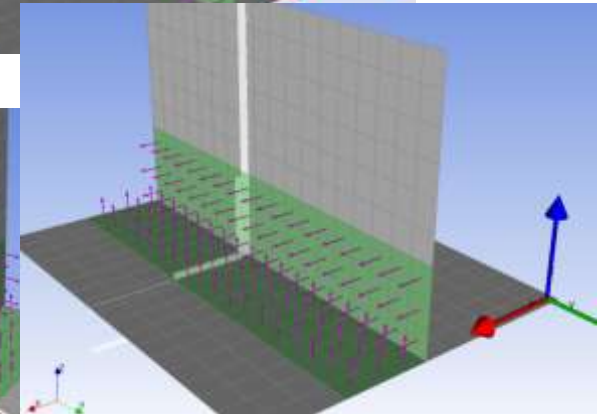
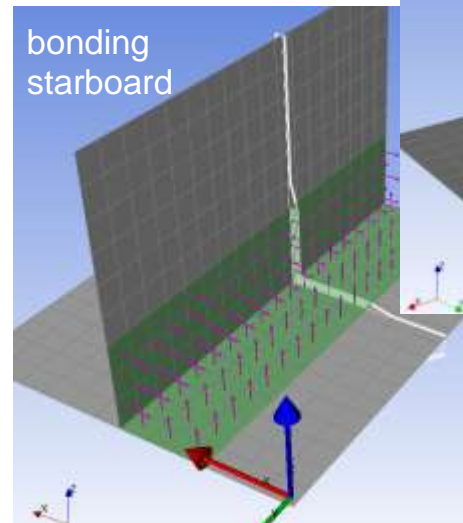
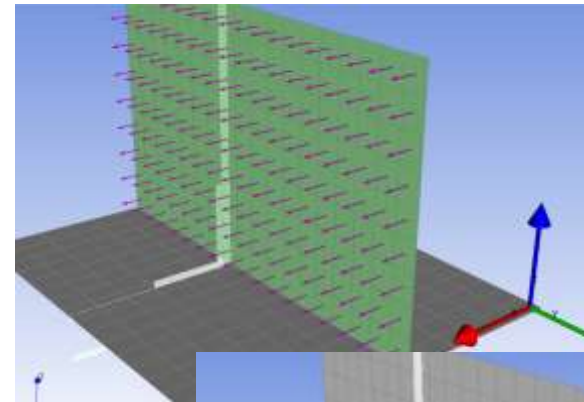
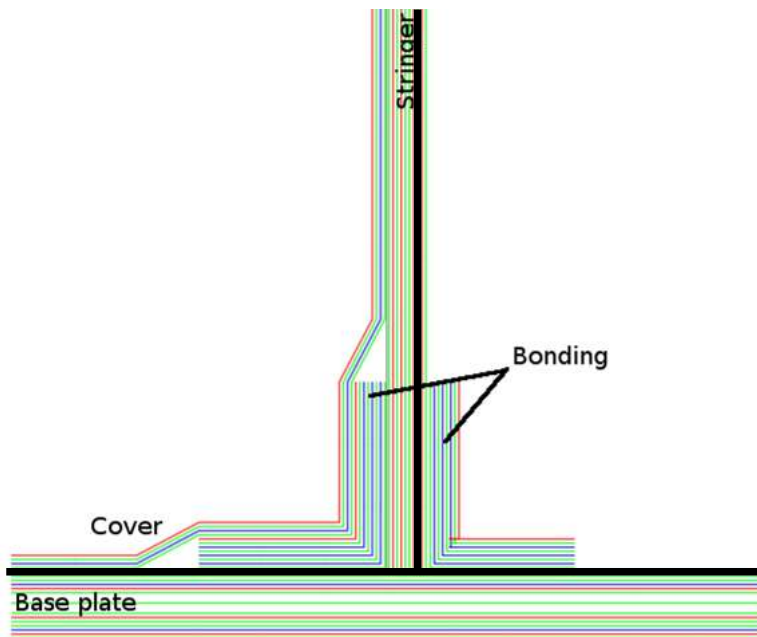


Shell-based Composite Analysis

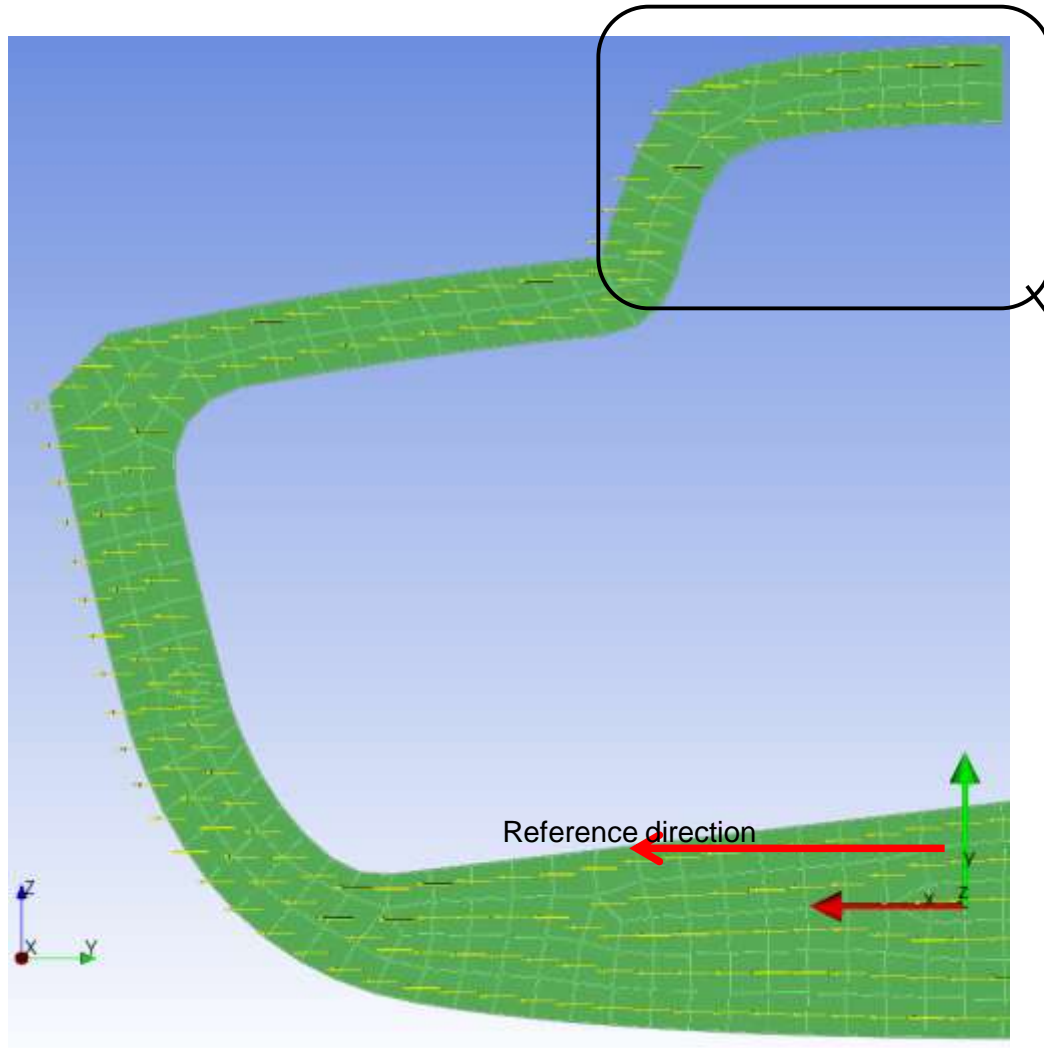
Stringer

How to manage arbitrary layup directions?

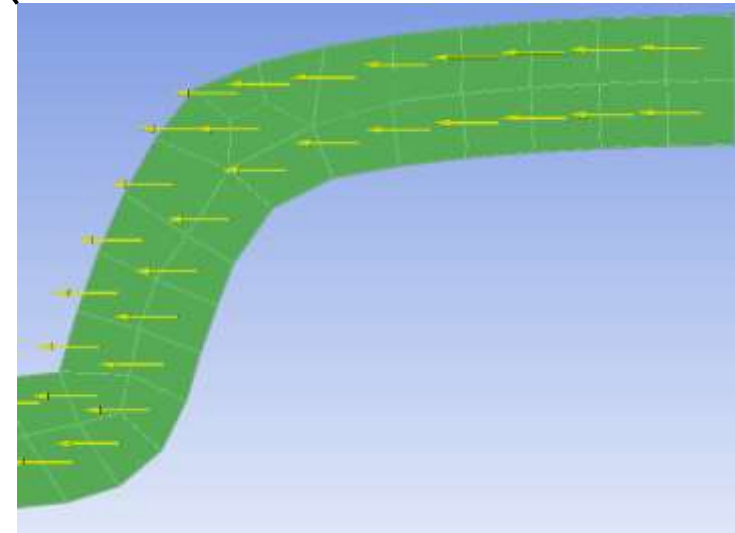
- Define Oriented Element Sets based on Mechanical's Named Selections
- Define multiple Layup Directions per Element



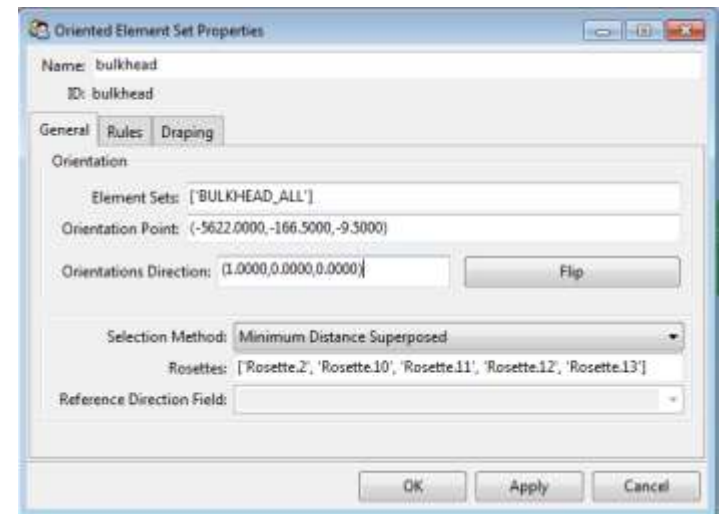
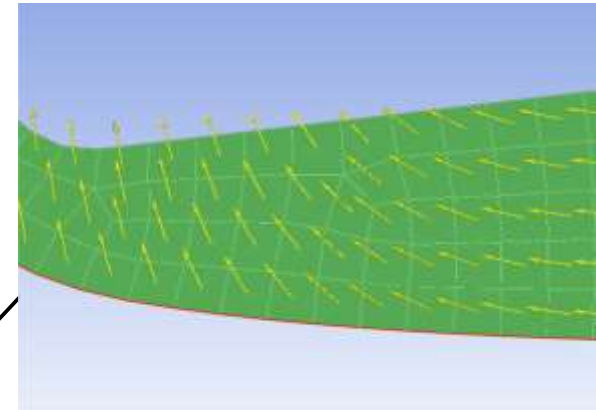
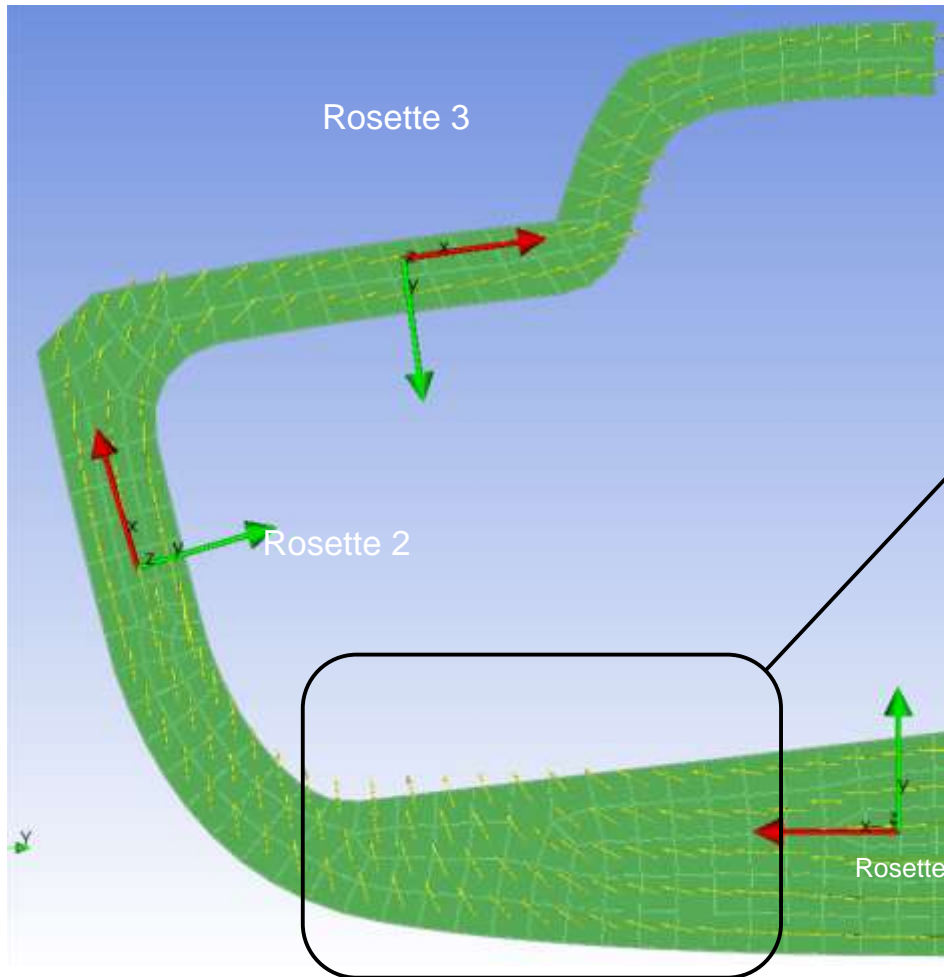
Shell-based Composite Analysis



- Cartesian, cylindrical, spherical and edge-wise rosettes
- Combination methods



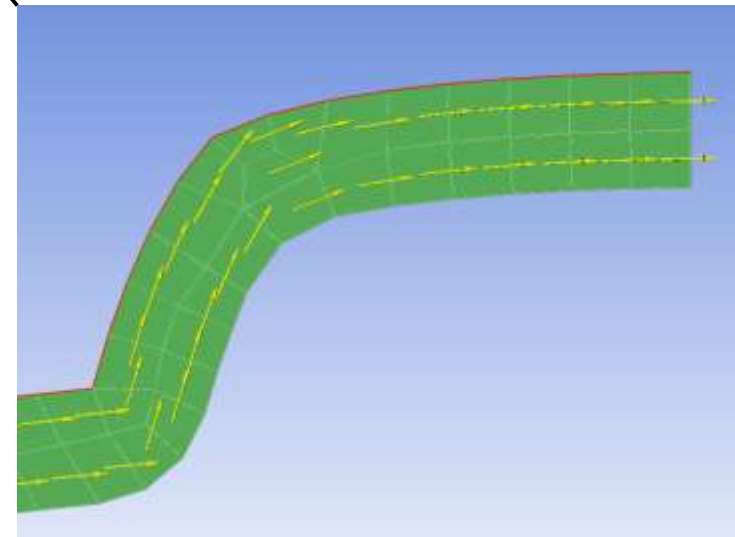
Shell-based Composite Analysis



Shell-based Composite Analysis

Edge set

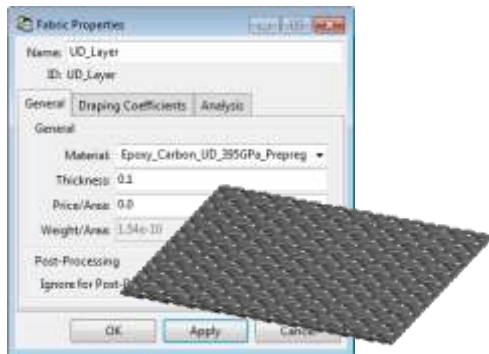
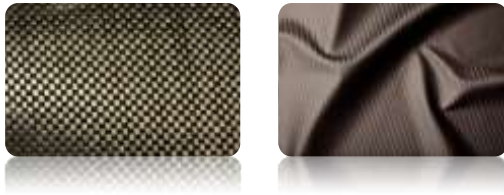
Edge-wise rosettes are very handy to define the reference direction along an edge guide



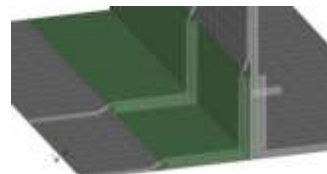
Shell-based Composite Analysis

Three steps to a composite layup

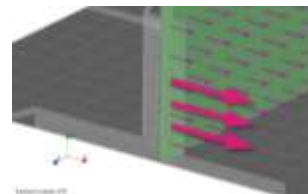
Material and Fabrics



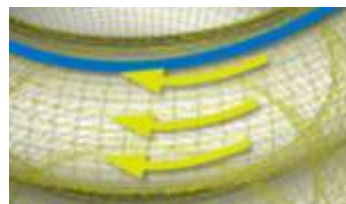
Oriented Element Sets



Layup Surface

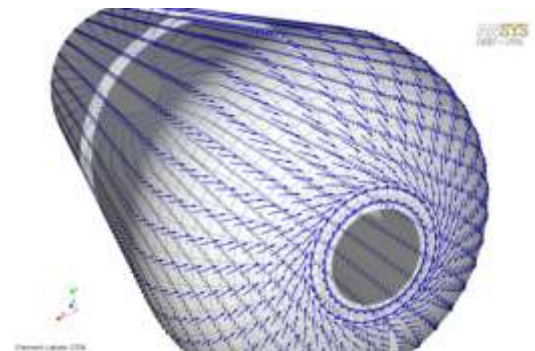
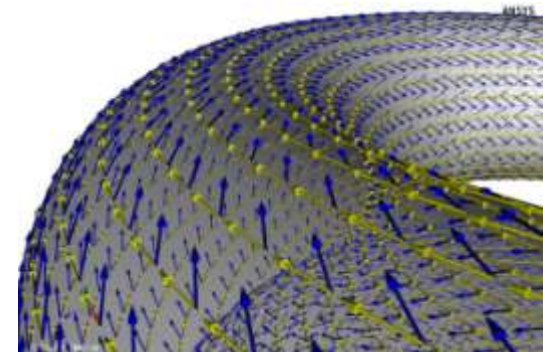


Layup Direction



Fiber Orientation

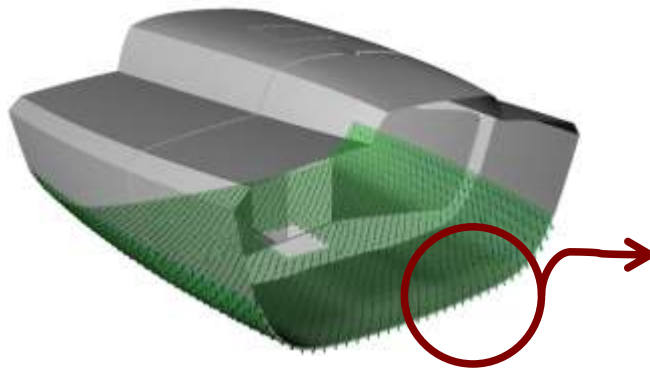
Composite Layup



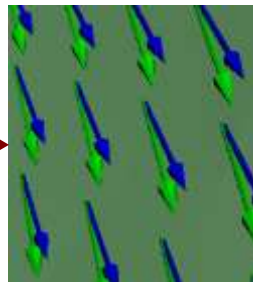
Shell-based Composite Analysis

Draping Algorithm is fast, intuitive and capable of handling complex shapes

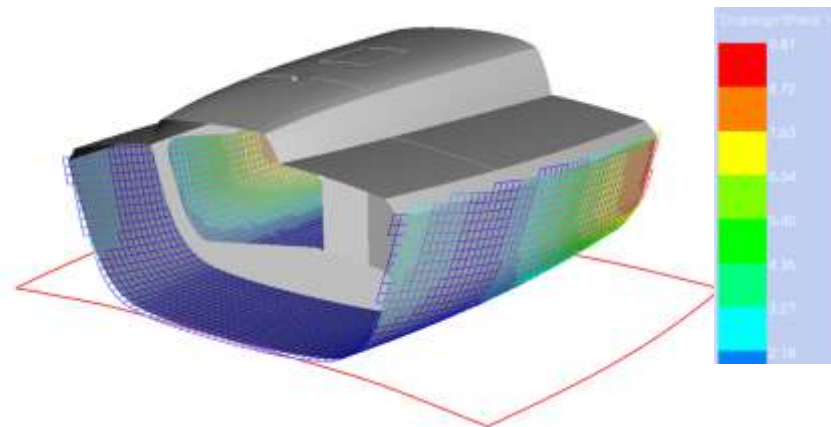
Draping Algorithms determine draped fiber orientations



Draping Mesh shows shear induced by draping

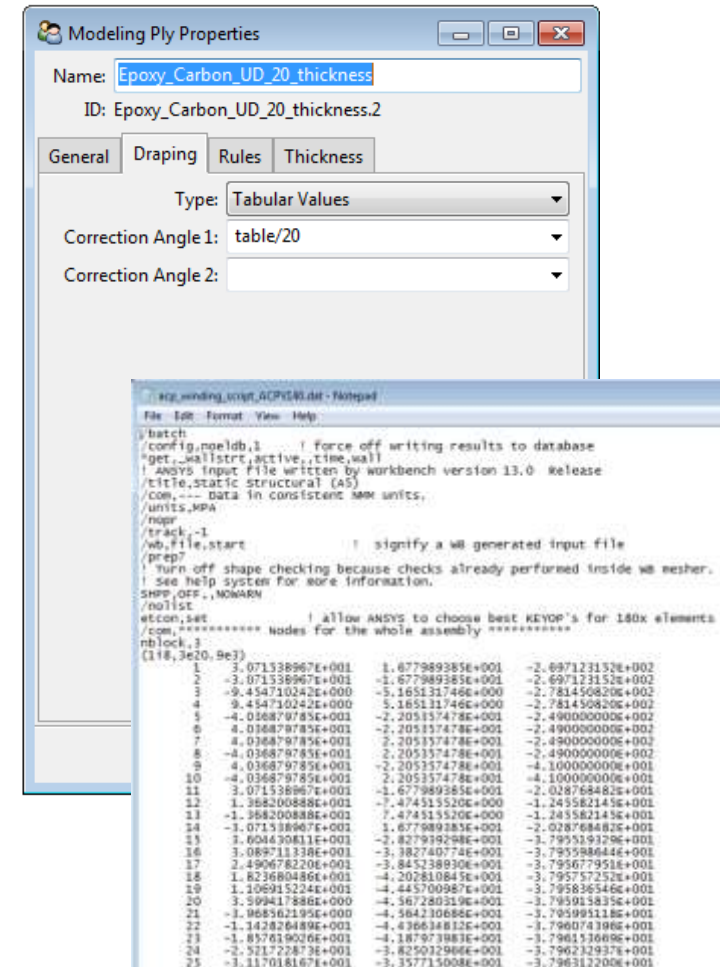
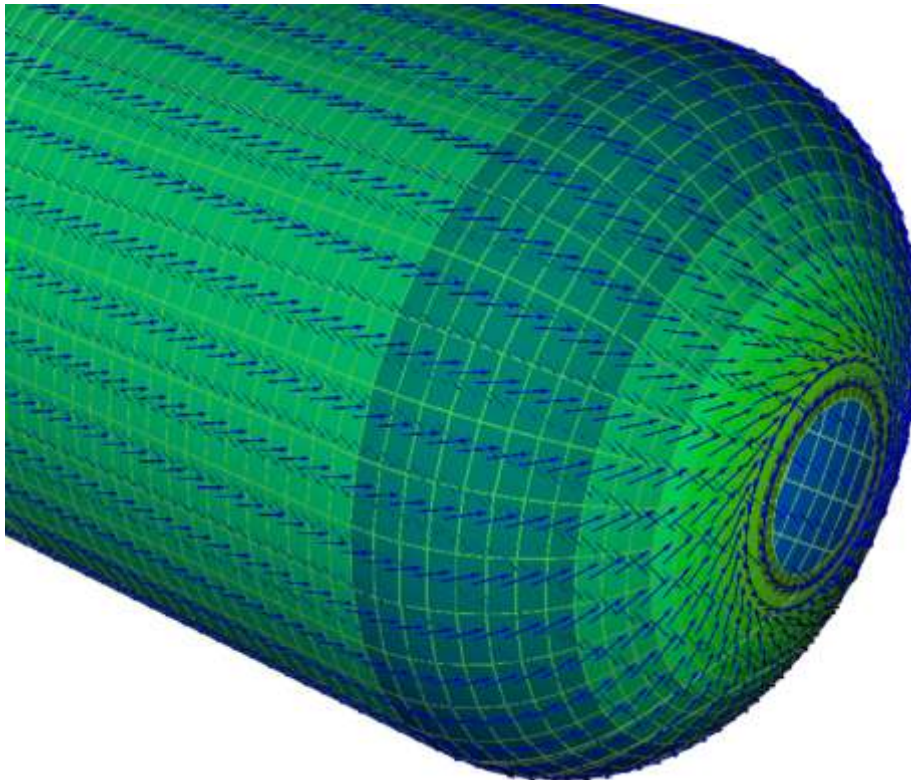


Flatwrap visualization can be exported for ply-cutter



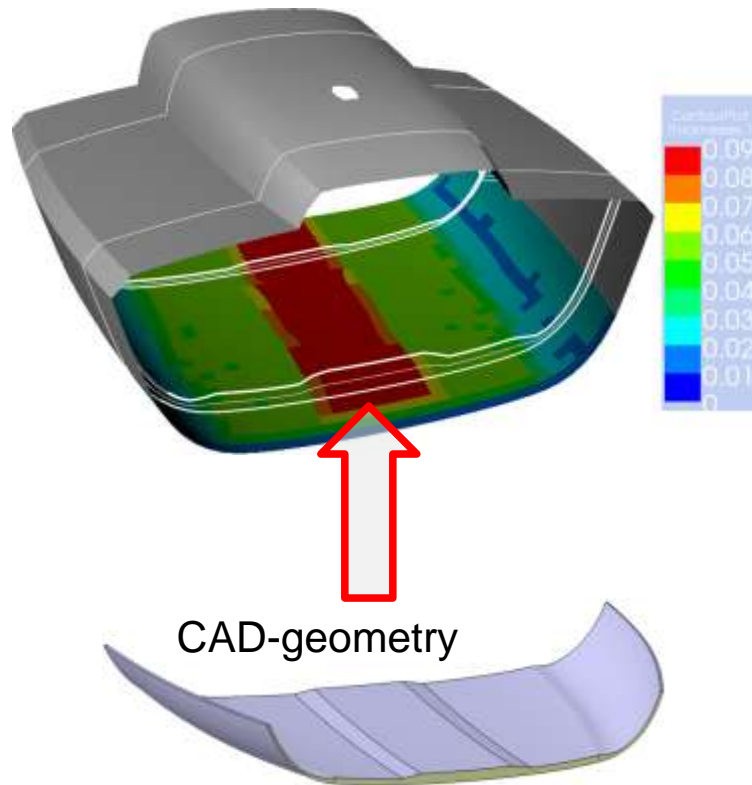
Shell-based Composite Analysis

E.g. for filament winding



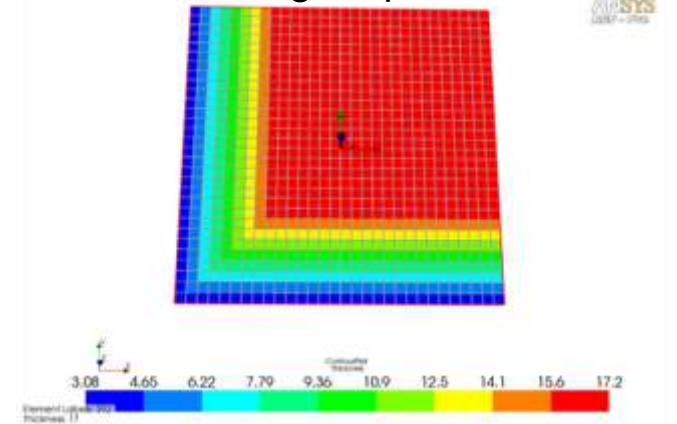
Shell-based Composite Analysis

Core thickness set by CAD geometry



CAD-geometry

Core edge taper

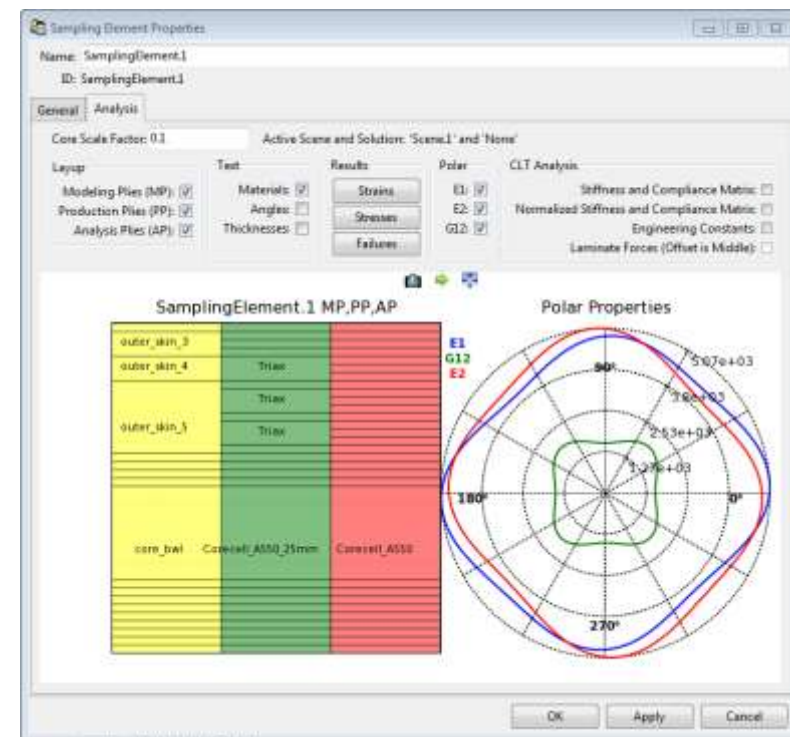
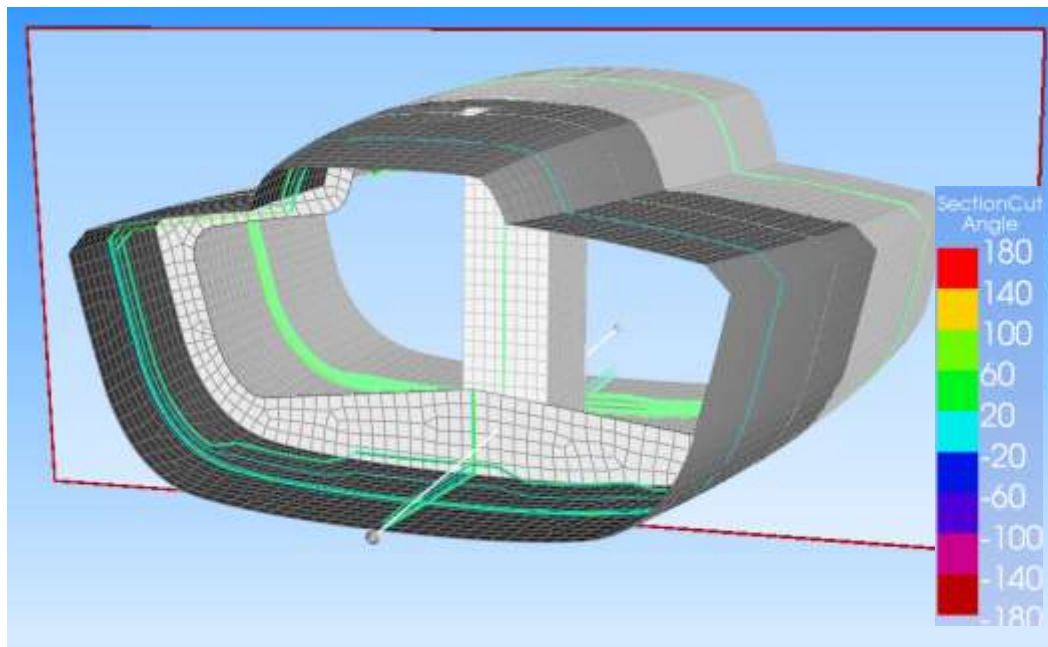


Ply thickness entered with a Look Up Table

A screenshot of a software window titled "Look Up Table Properties". It displays a table with multiple columns, including "Layer", "Material", "Thickness", and "Ply Thickness". The table contains data for various layers and materials, with values for thickness and ply thickness.

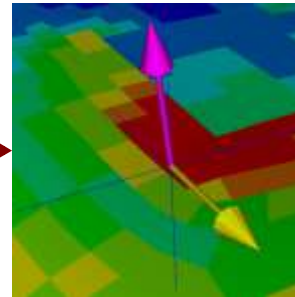
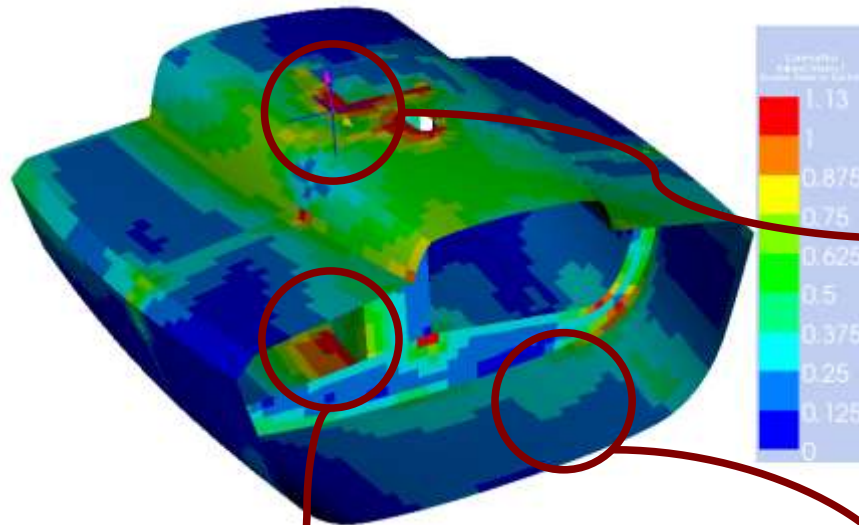
Shell-based Composite Analysis

- Stacking sequence and composite thickness can be displayed on arbitrarily Sections or the entire model
- Sampling elements are a powerful tool to analyze the layup

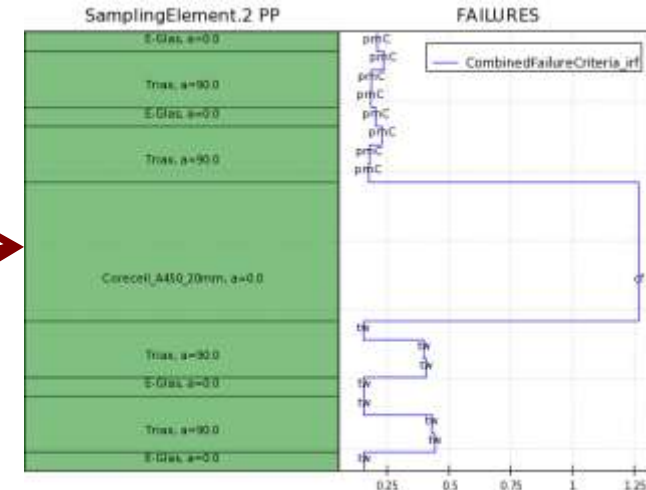


Shell-based Composite Analysis

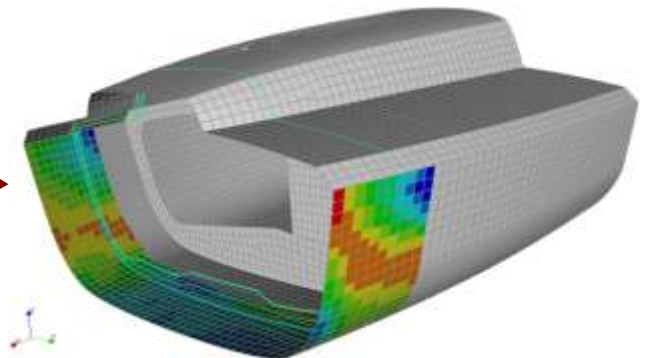
IRF plot of entire structure



Assess utilization of each ply with a Sampling Element



Analyze structure ply-by-ply



Tw(15)(2):
Tsai-Wu
Layer 15,
Loadcase 2

Gain an overview of
critical failure mode,
layer and load case

CADFEM

Shell-based Composite Analysis

Solid Composite Analysis

Summary

Changelog ACP

Preview Composites

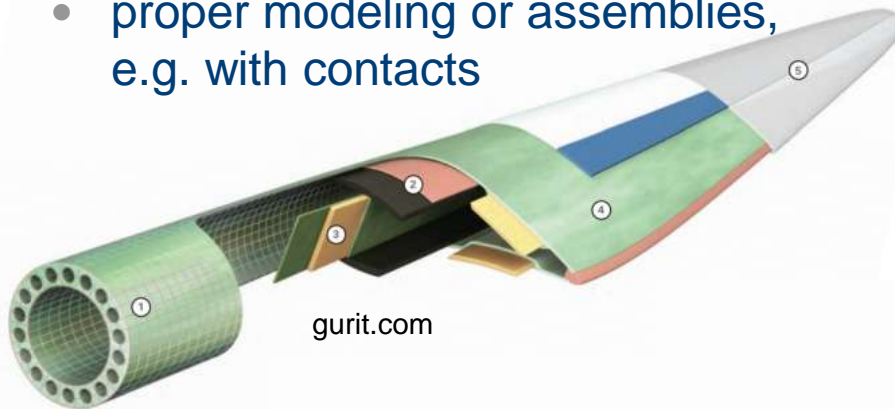
Why Solid Modeling?

Account for

- out-of-plane normal stresses
- out-of-plane shear stresses

Relevant for

- „thick-walled“ composite structures
- e.g. buckling analyses of such
- proper modeling of assemblies, e.g. with contacts



gurit.com

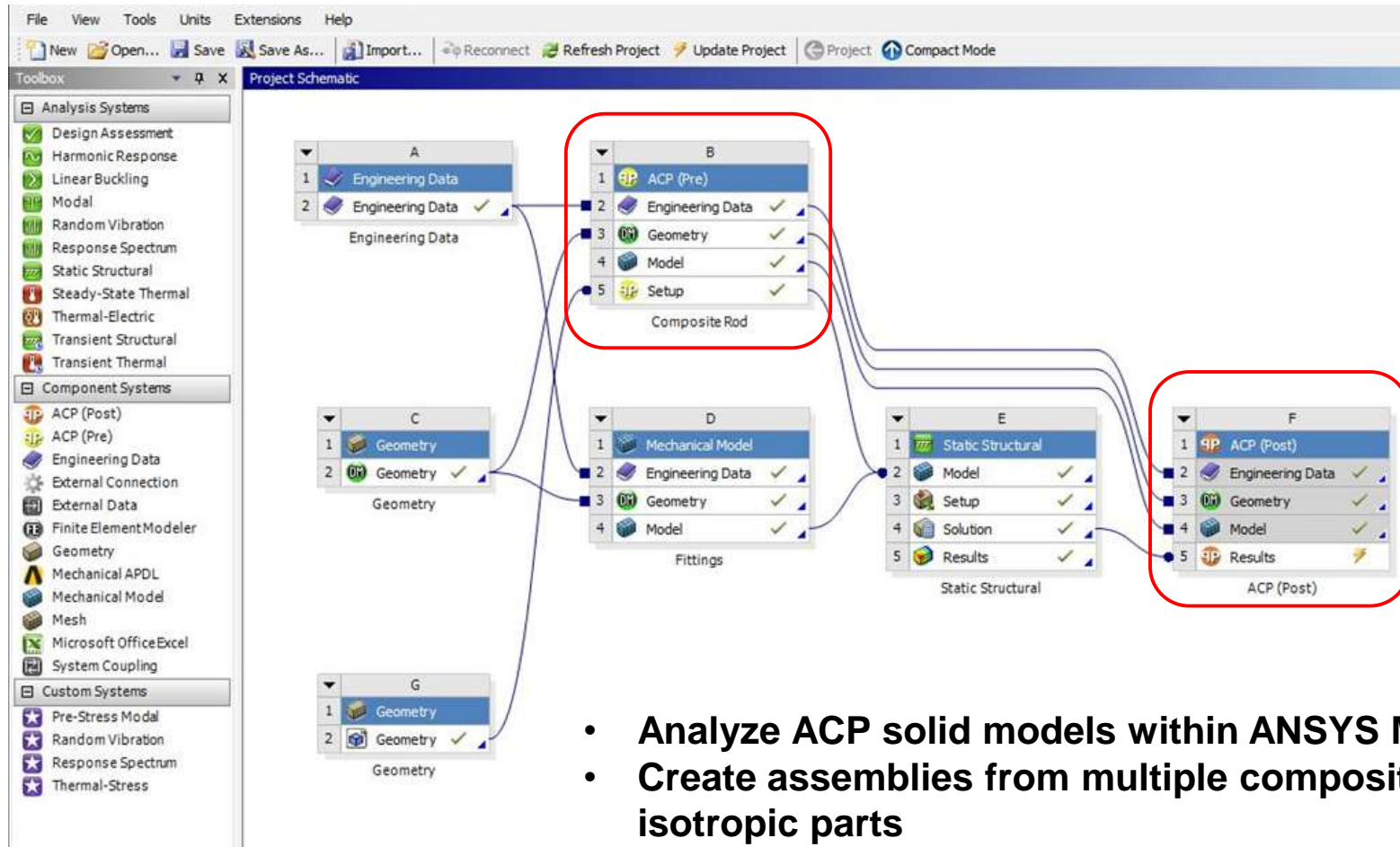


gereports.com



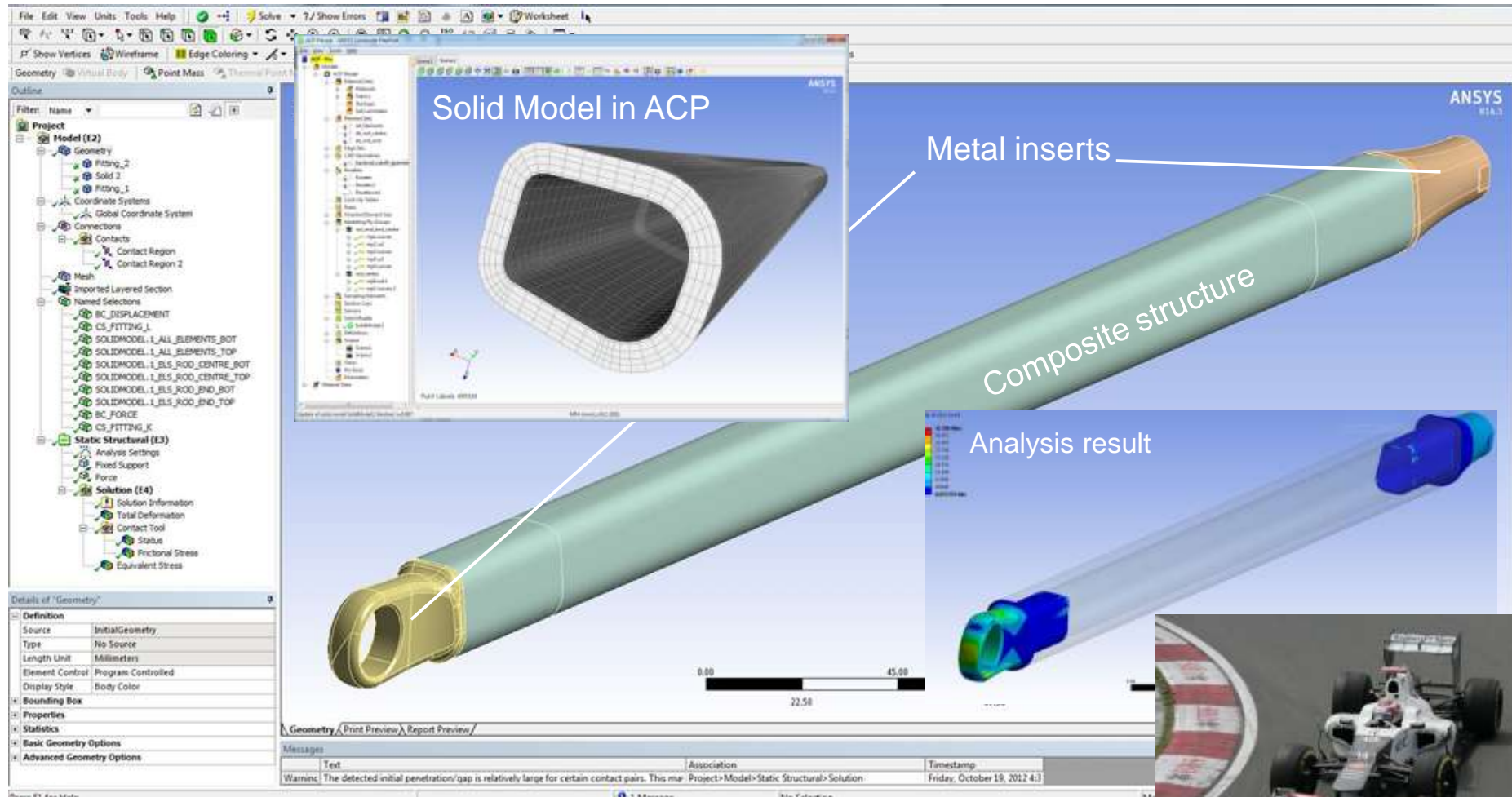
wind-watch.org

Solid Composite Analysis



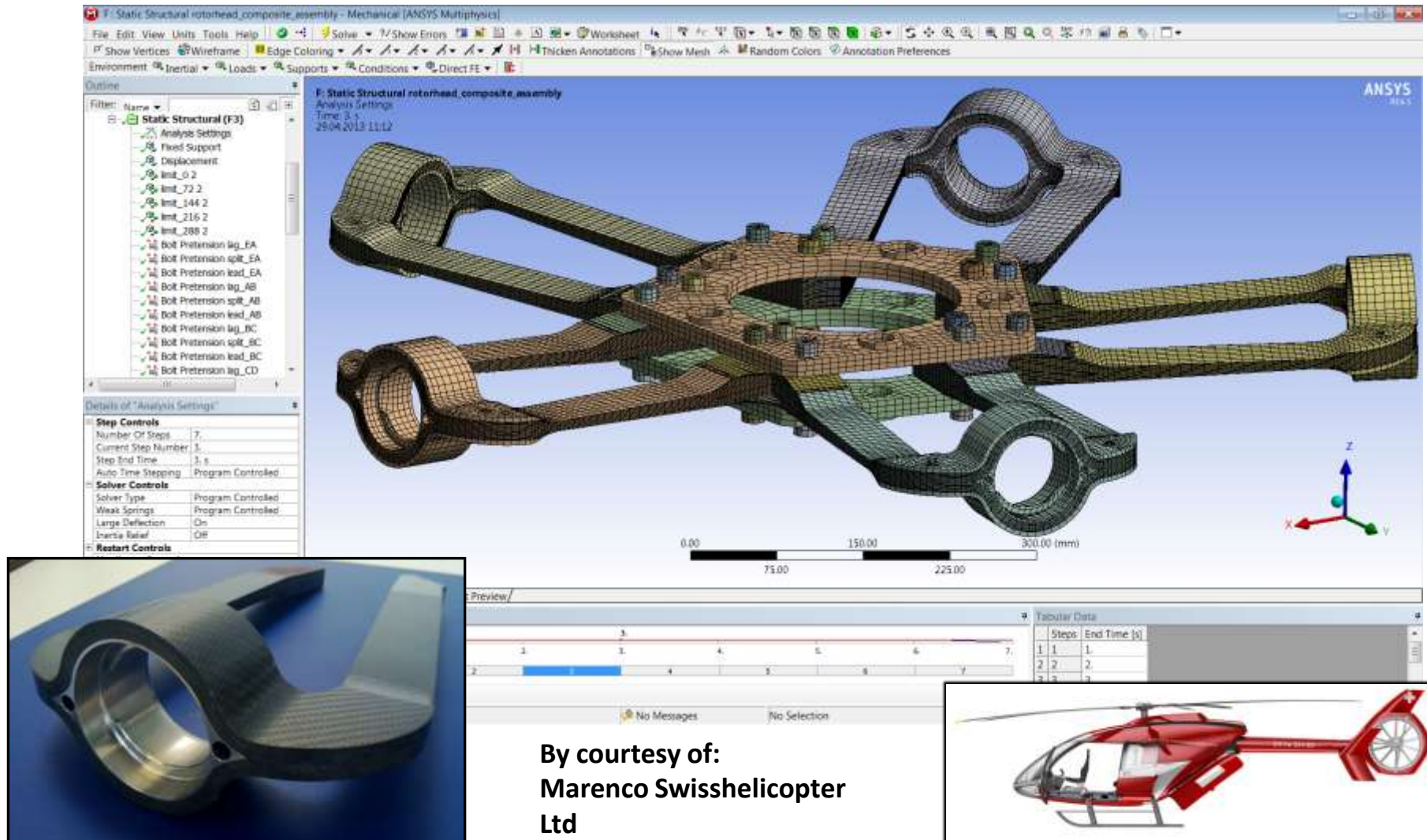
- Analyze ACP solid models within ANSYS Mechanical.
- Create assemblies from multiple composite and isotropic parts
- Apply the full ACP post-processing to solid models

Solid Composite Analysis

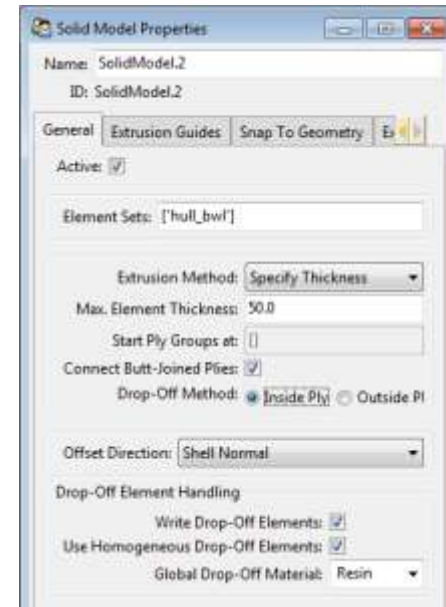
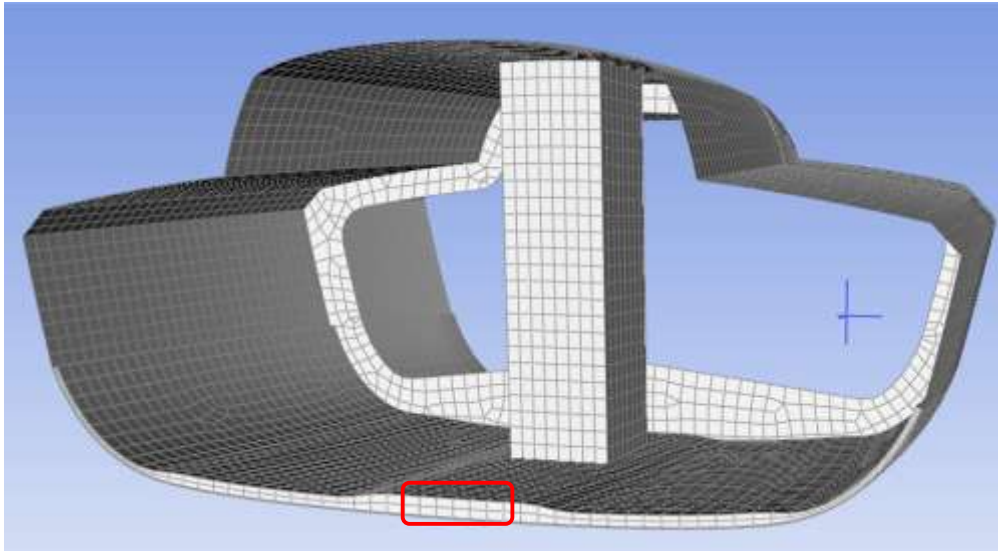


By courtesy of: Sauber F1 Team

Solid Composite Analysis



Solid Composite Analysis

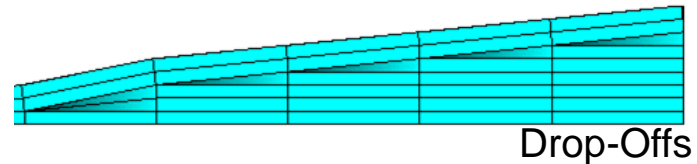
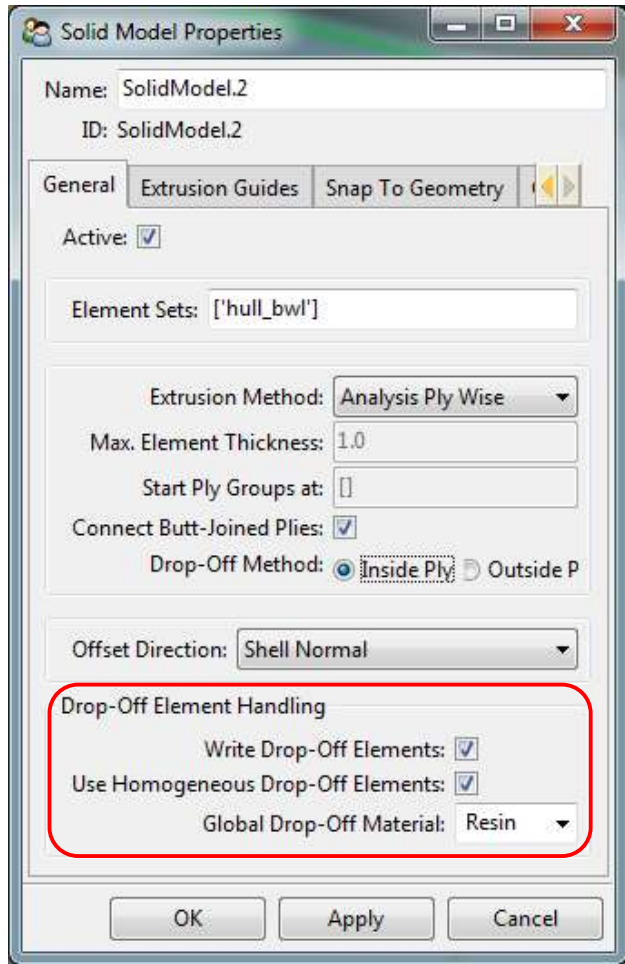


Monolithic

Material-wise

Analysis Ply-wise

Solid Composite Analysis



- New option to model drop-offs with homogeneous resin elements.
- Automatic removal of bad elements
- Caching computed solid models allows to quickly restore them on reload and update of the ACP model.

Solid Composite Analysis

- An Extruded Solid Model can be additionally shaped with external geometries to generate desired shapes

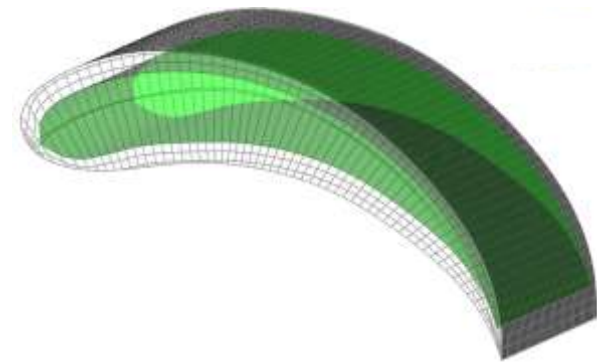
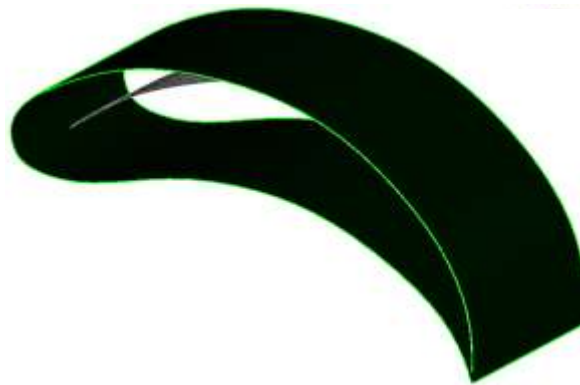
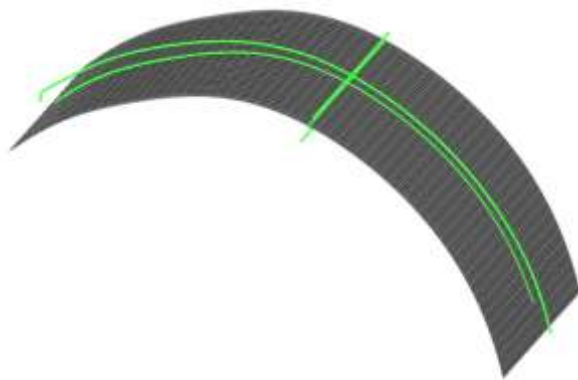
**Start with shell geometry
and composite layup**



**Define extrusion guides
and snap to geometry**

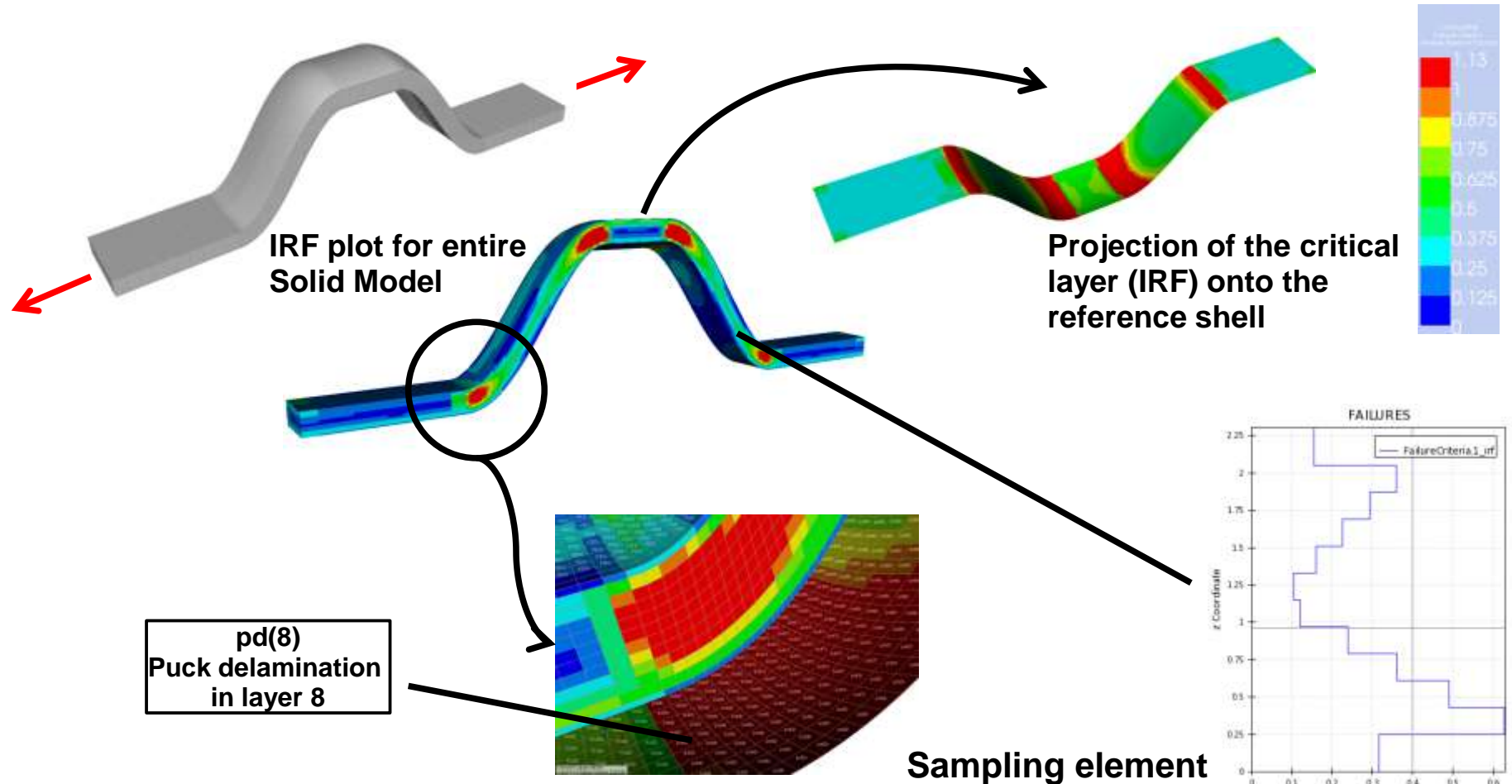


**Specify element thickness
and extrude Solid Model**



Solid Composite Analysis

All features of Shell-Model Postprocessing are retained



CADFEM

Shell-based Composite Analysis

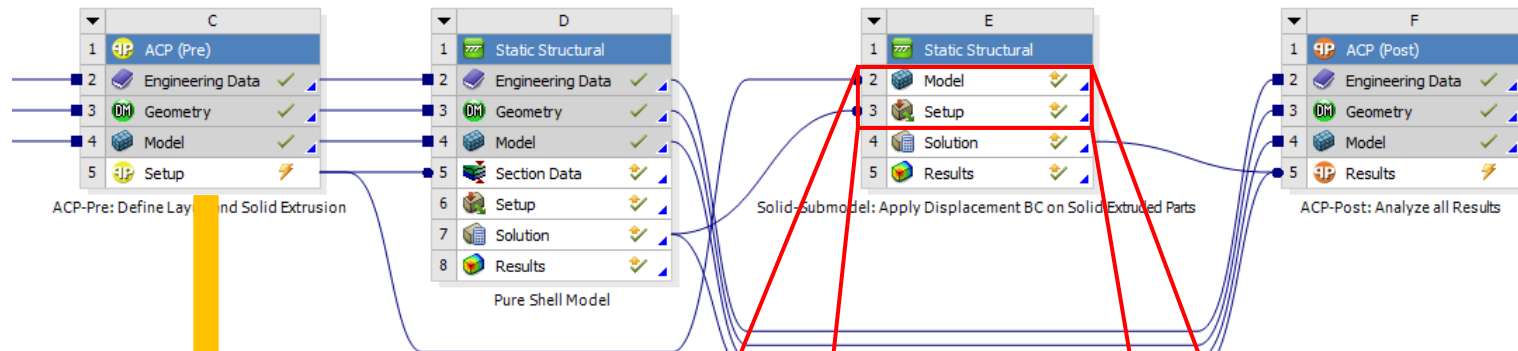
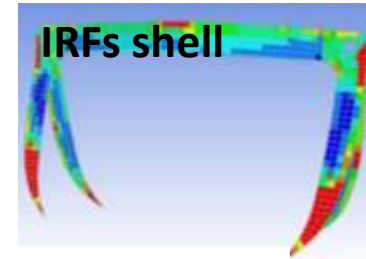
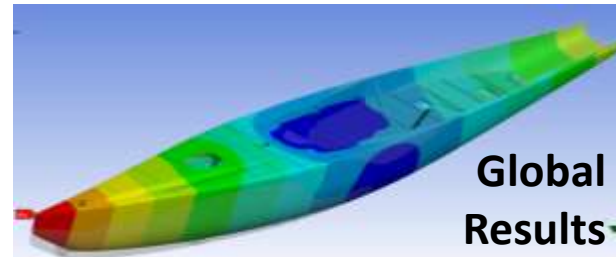
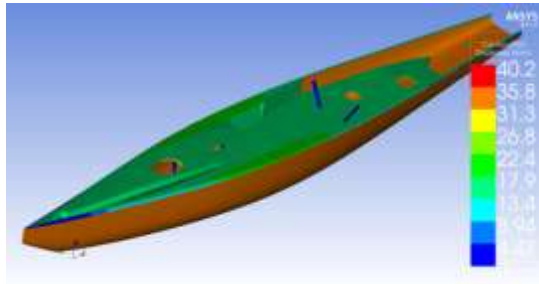
Solid Composite Analysis

Additional Features

Preview Composites R15.0

Additional Features

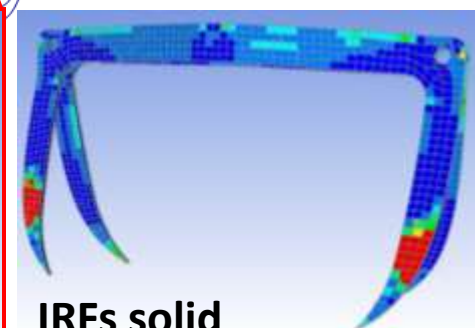
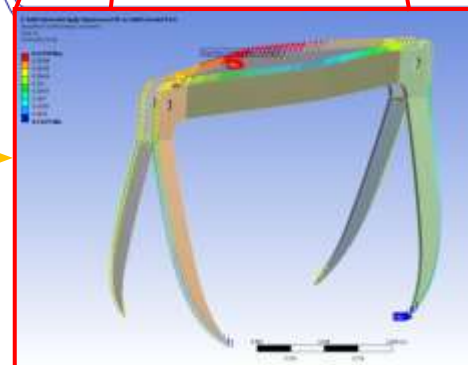
SHELL



SOLID

Create solid model of critical part (C5 – E2)

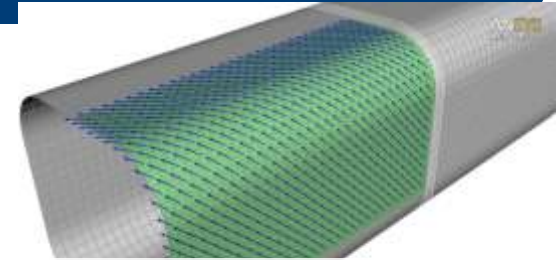
and map shell results to the cut faces (D7 - E3)



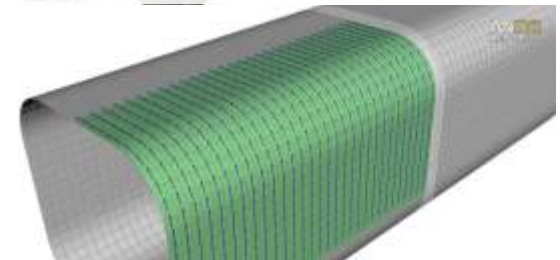
Additional Features

Composite Parameter Studies

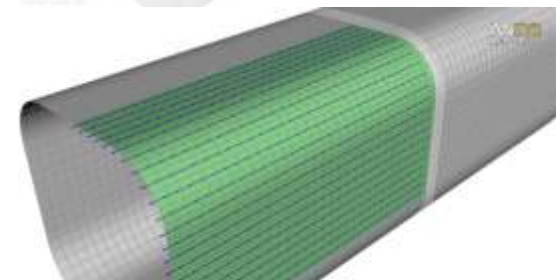
- ANSYS Composite PrepPost allows the user to define parameters for fiber angles.
- All parameters are accessible in the ANSYS Workbench parameter manager.



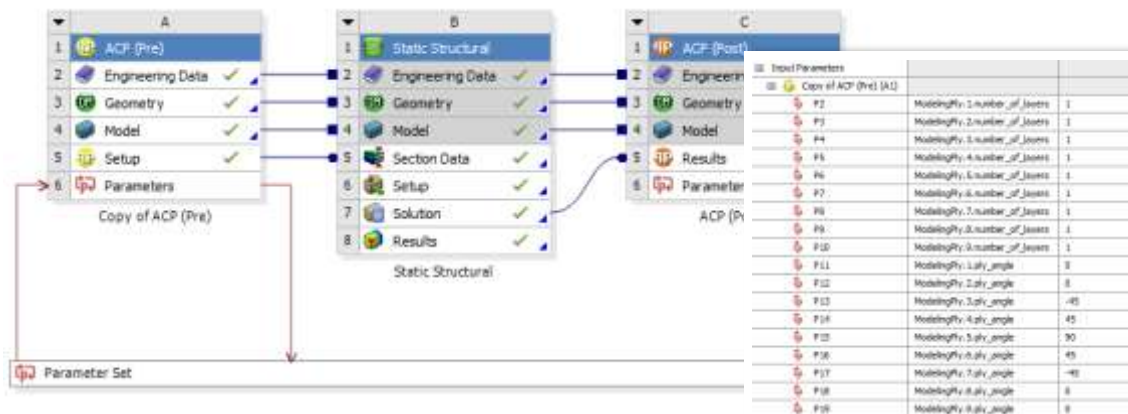
45° Layer



90° Layer



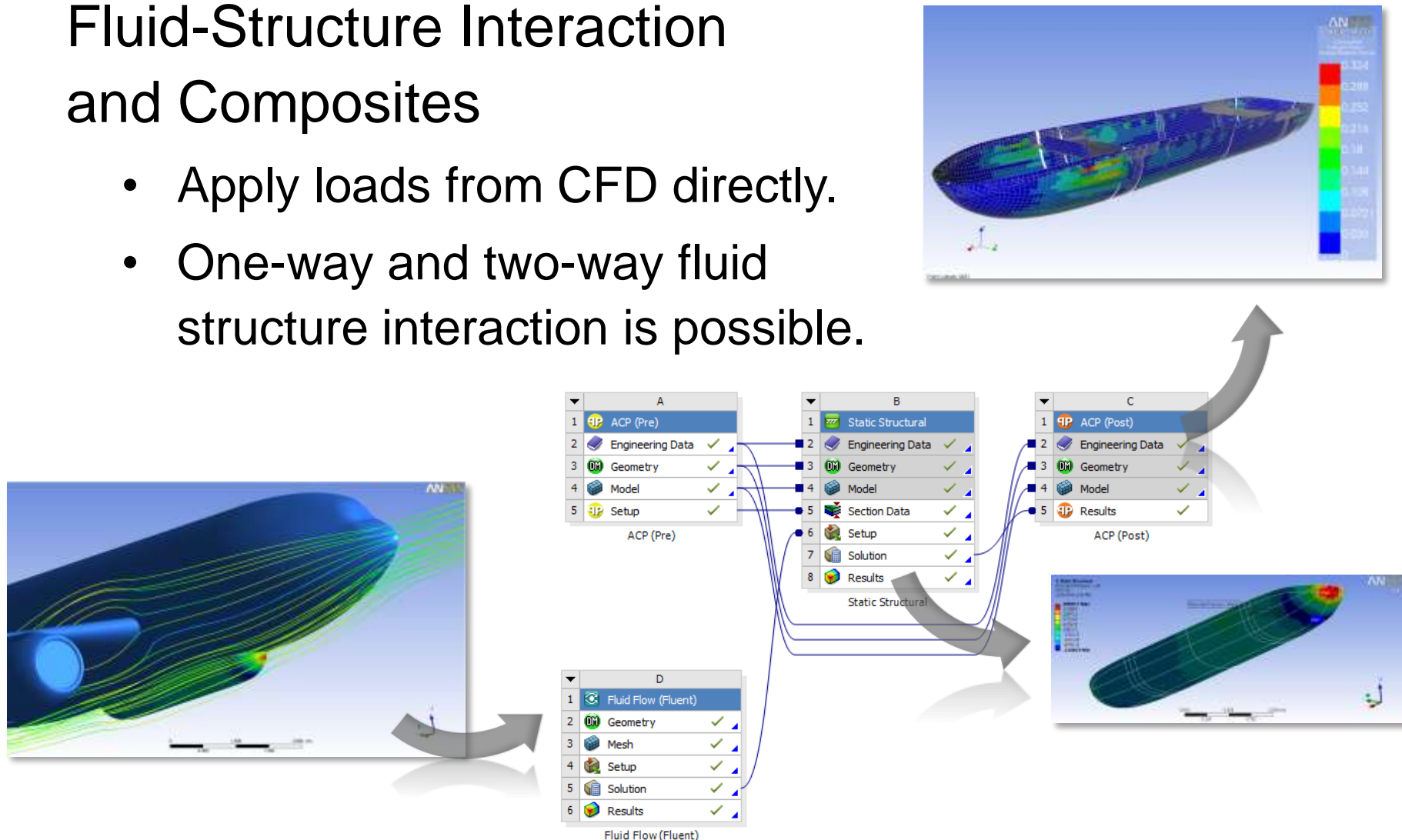
0° Layer



Additional Features

Fluid-Structure Interaction and Composites

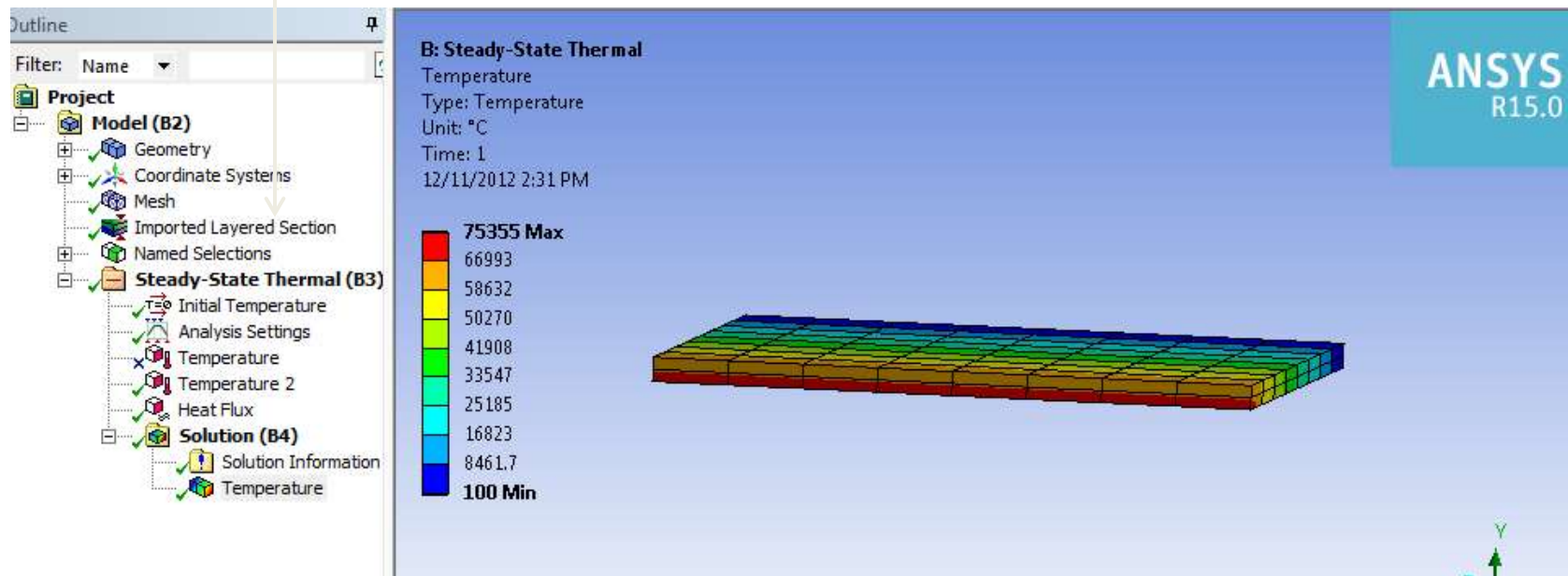
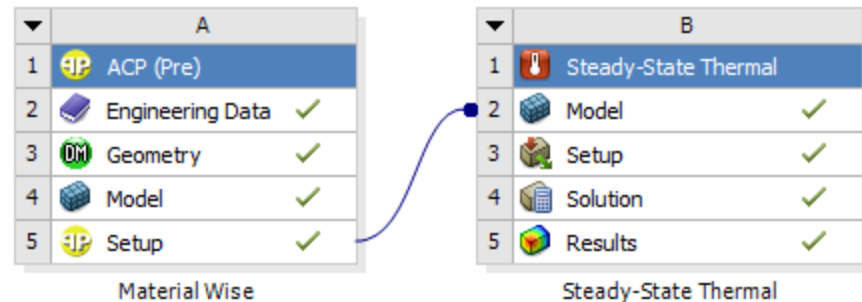
- Apply loads from CFD directly.
- One-way and two-way fluid structure interaction is possible.



Additional Features

Thermal analysis now supports solid layer elements SOLID278/SOLID279

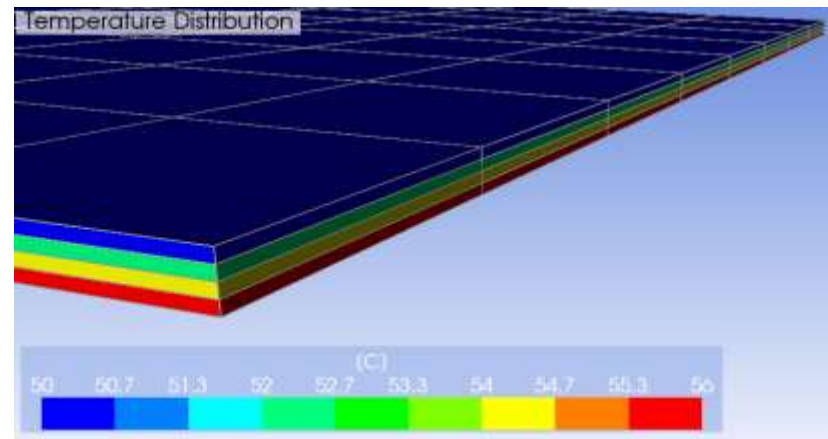
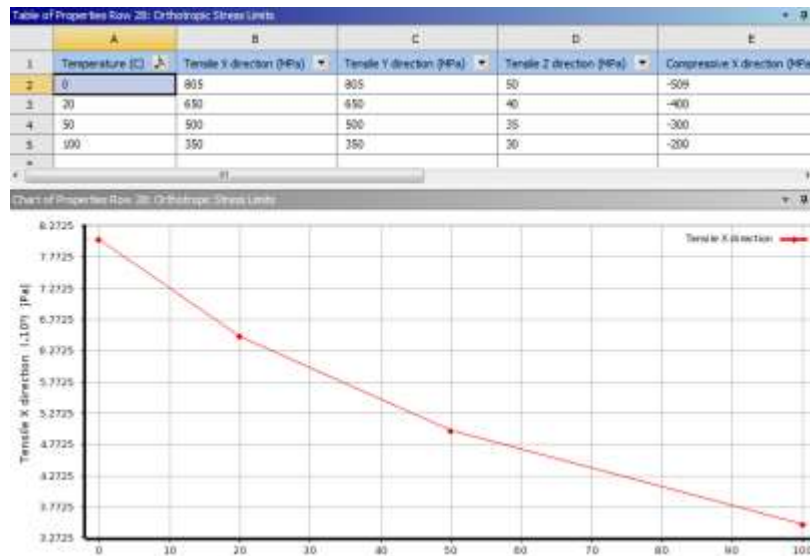
Thermal solid composites are now supported in models with Imported Layered Sections.



Additional Features

ACP Post supports evaluation of temperature dependent strength and Failure Criteria given the following additional data:

- Temperature dependent material properties
- Computed layered element temperatures



Additional Features

Interface delaminations can now be modeled in Mechanical:

Supported techniques to define failure criteria:

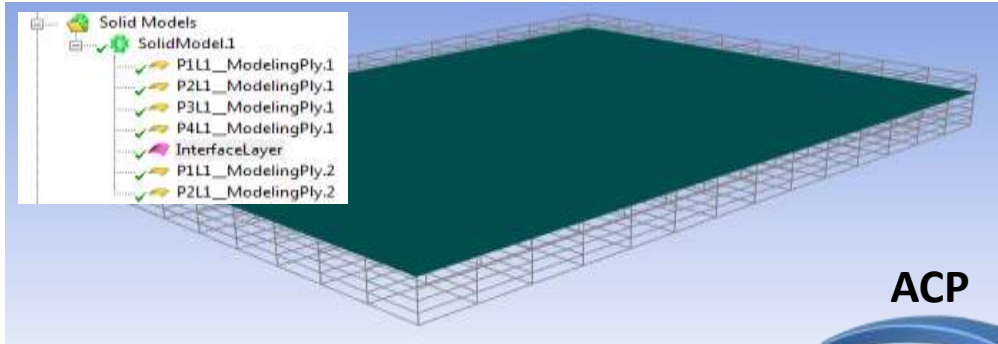
- Virtual Crack Closure Technique (VCCT)
- Cohesive Zone Model (CZM)

Definition:

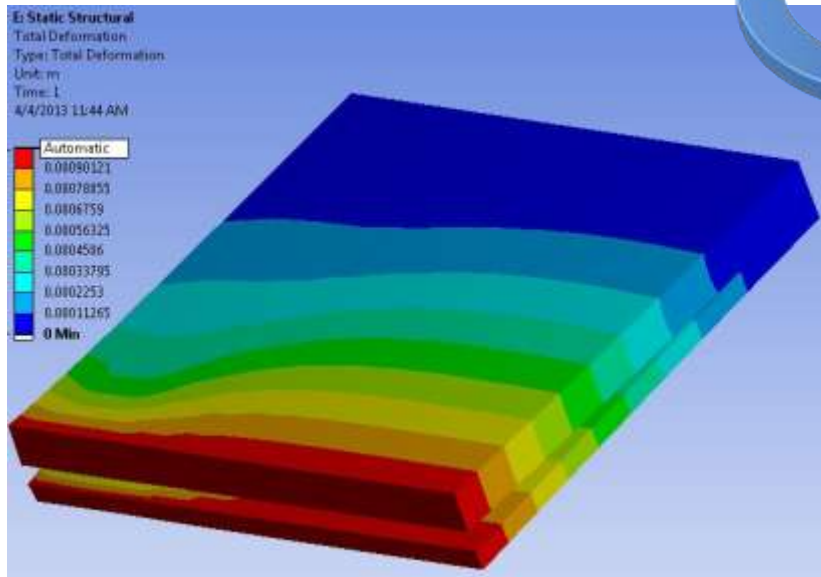
1. Define CZM material properties/ VCCT fracture criteria in ED
2. Create delamination interface in ACP or Mechanical
3. Configure and run crack growth analysis in Mechanical

Additional Features

Center FEM



ACP



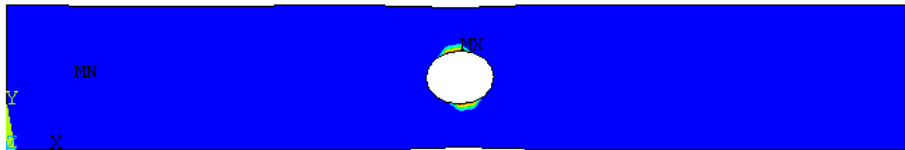
Project

- Model (E2)
 - Geometry
 - Solid 1
 - Solid 2
 - Coordinate Systems
 - Connections
 - Mesh
 - Fracture
 - Pre-Meshed Crack
 - Interface Delamination
 - Imported Layered Section
 - Named Selections
 - Static Structural
 - Details of "Interface Delamination"

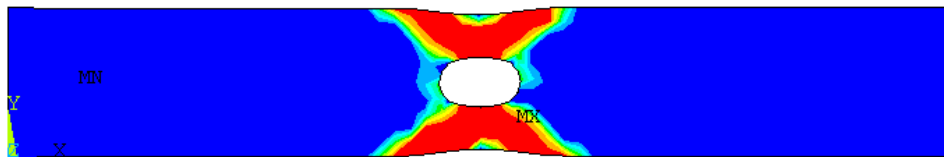
Definition	
Type	Interface Delamination
Method	VCCT
Failure Criteria Option	Energy-Release Rate
<input type="checkbox"/> Critical Rate	1. J/m ²
Suppressed	No
Scope	
Generation Method	Pre-Generated Interface
Interface	InterfaceLayer.1
Initial Crack	Pre-Meshed Crack
Step Controls for Crack Growth	

Additional Features

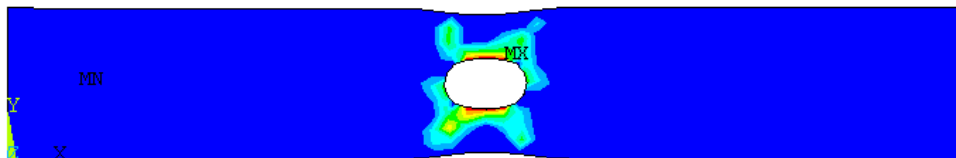
- New nonlinear solution process to simulate the damage propagation in composites beyond first ply failure
- Damage evolution with Continuum Damage Mechanics (CDM) method
- Example: progressive damage of a composite plate under stretch load



Start of damage (layer 1)

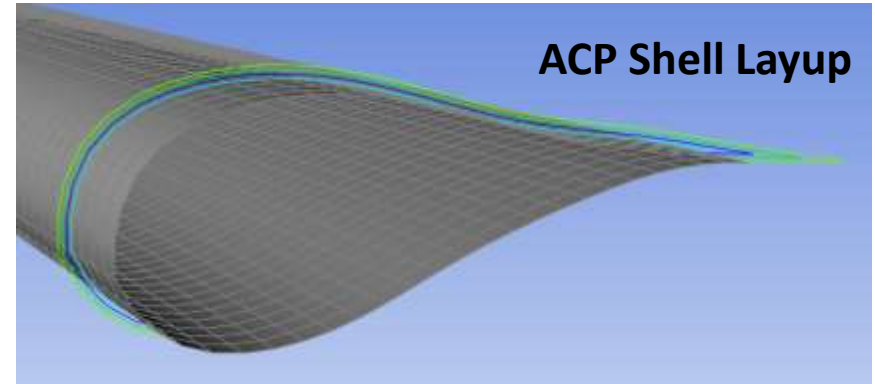
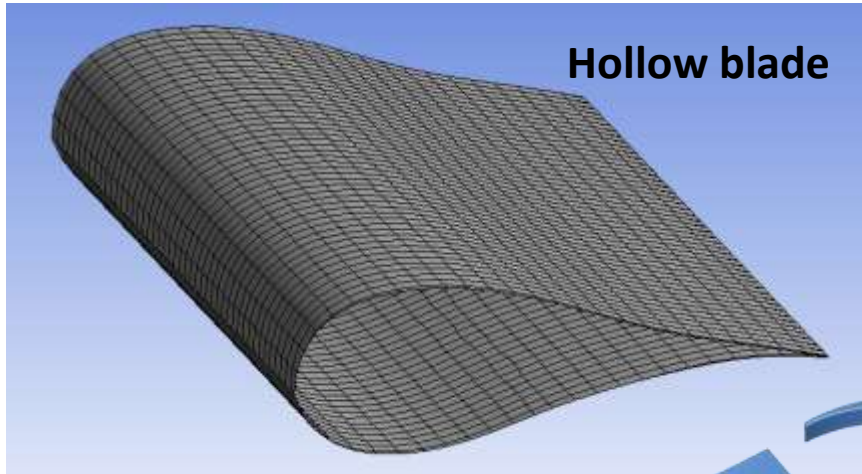


Progressed damage
(layer 1)

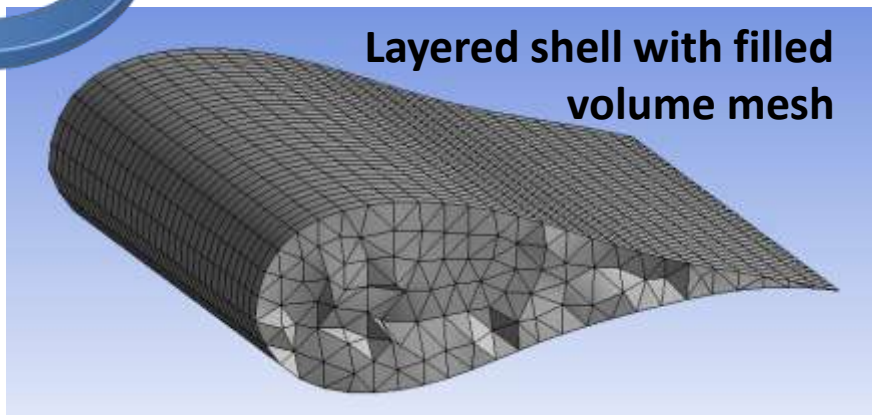
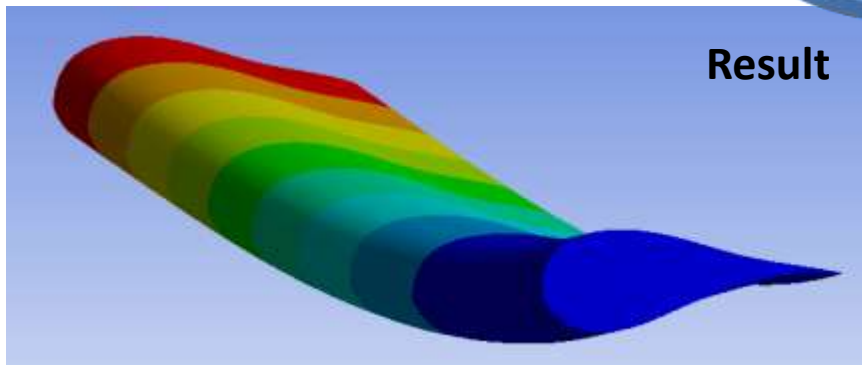


Progressed damage
(layer 3)

Additional Features



**Combined ACP Solid
Model with shell mesh**



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Shell-based Composite Analysis in R14.5

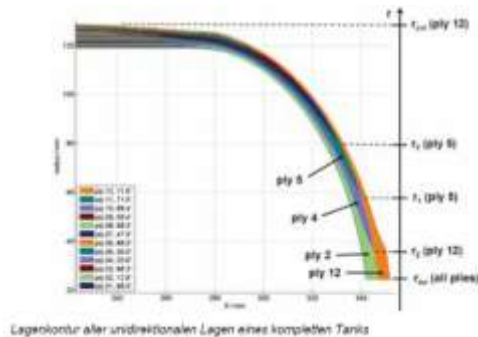
Solid Composite Analysis in R14.5

Additional Features

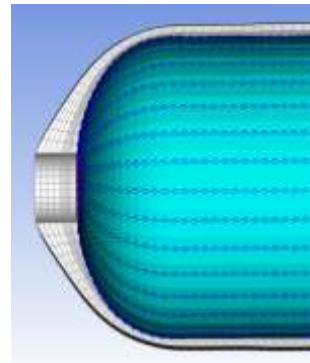
Preview Composites

Specific functionality for winded and braided plies

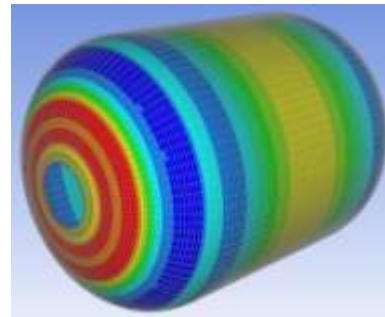
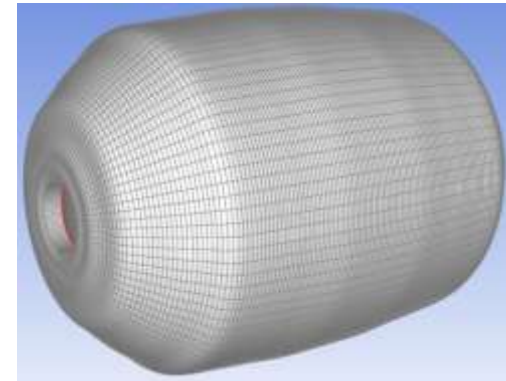
- Complex laminate properties (thickness, sequence and fiber orientations) in the pole regions
- Layup in ACP is directly derived from winding simulation



Import
winding
data

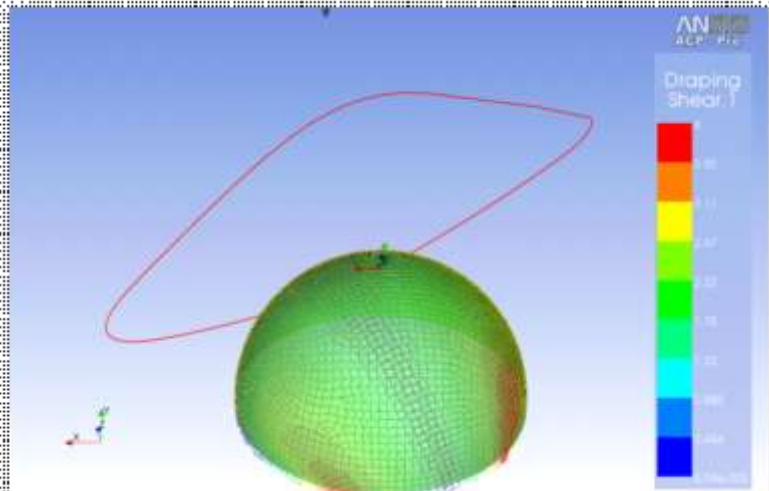


Export
shell or
solid
model



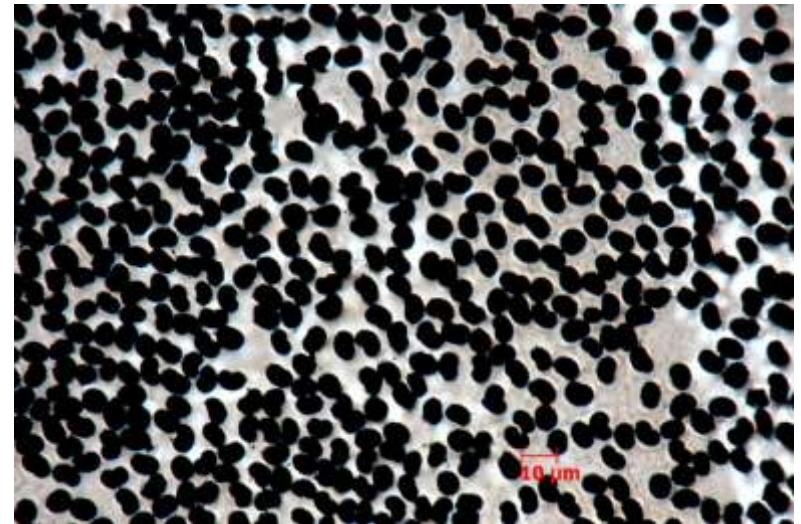
Shear Dependent Material Models for Woven Materials

- Draping simulation can compute
 - Effective fiber directions
 - Thickness variations
 - Shear of woven materials
- Material shear significantly affects the material properties
- Consider shear dependent material properties in the analysis



Material Degradation Models (Knock-down factors)

- Due to manufacturing process related issues the quality of composite material is not constant over a part.
- Areas of reduced quality are often known upfront or can be identified by destructive as well as non-destructive inspection methods.
- There shall be an option based on look-up tables to define degradation-values dependent on locations for certain material properties



Fatigue Analysis for Composites

- Prominent topics with composite structures.
- Classical models based on macroscopic material-models requires a huge amount of test-data. For general laminates this approach is not feasible
- Fatigue-models have to be able to calculate stresses and strains for fibers and matrices based on the nodal solutions for every model.
- Fatigue then can be evaluated for fiber and matrix separately for every layer within every element relying only on a limited set of material-data for fibers and matrix.



Summary

- ✔ Intuitive workflow for composite modeling
- ✔ Quick postprocessing
- ✔ Solid modeling of composites
uses the same workflow
- ✔ Composite design studies - Optimize your design
before you build the first prototype
- ✔ Simple “drag-and-drop” multiphysics
- ✔ One single framework - ANSYS Workbench

Contact

CADFEM GmbH
Geschäftsstelle Frankfurt

Timo Frambach

Tel.: +Tel: +49 (0) 6196-76708-21

Mobil: +49 (0)160 8970338

Fax: +49 (0) 6196-76708-44

E-Mail: tframbach@cadfem.de

Vielen Dank für Ihr Interesse!