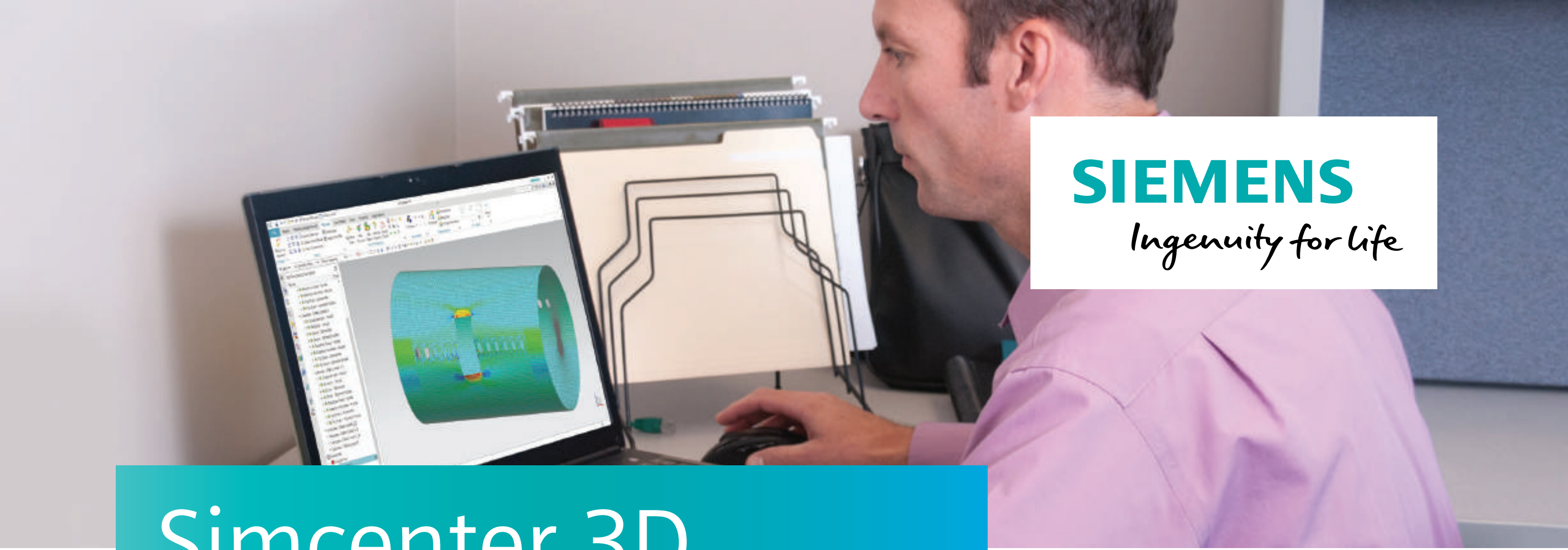


Simcenter 3D for composites

Increasing structural efficiency and reliability while minimizing weight on a collaborative platform

Benefits

- Achieve weight reduction targets and provide safe, durable structures
- Design as manufactured and for manufacturability
- Control and reduce development costs with efficient integrated workflows
- Mitigate risk by controlling processes up front with a collaborative workbench
- Capture and identify the behavior of layered composite components, reducing the number of safety factors
- Move simulation upstream in the design process to achieve lighter structures

Summary

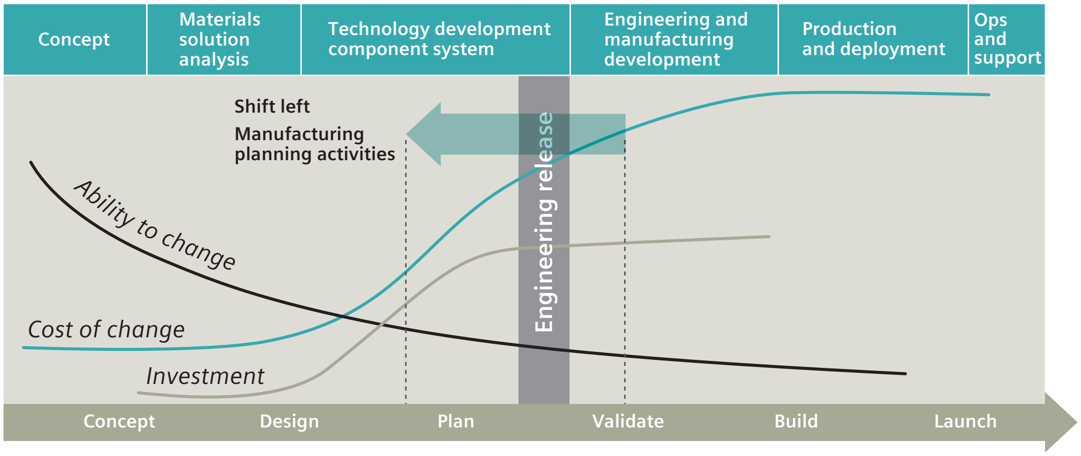
To compete in the evolving manufacturing market, companies need to adapt or diversify their production to accommodate ever stricter financial, regulatory and environmental constraints. Climate change challenges are leading our society to modify its behavior and favor sustainable and innovative products and equipment. Using composite materials is one way to meet this challenge, and represents a promising business opportunity.

The advantages of replacing traditional materials with composites include:

- Better performance
- Lighter weight
- Lower energy consumption
- Fewer greenhouse gas emissions

The potential scope of application is large and includes aerospace, automotive, energy, construction and shipbuilding among many industries in which the use of composites is growing continuously.

Many explore the option of replacing metallic parts with composite material equivalents, including solutions based on laminated materials of unidirectional fiber-reinforced polymers or woven fabric plies. Compared to a metallic material, composites offer a multitude of possibilities related to material types, fiber orientation and reinforcement architecture. Successfully using composite materials requires substantial improvements in the tools used for the end-to-end process, from virtual product design to manufacturing. From a



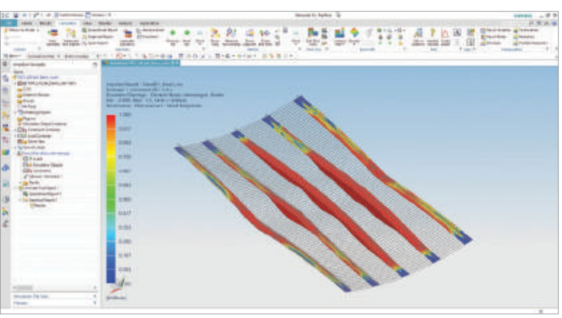
Simcenter 3D for composites

simulation perspective, evaluating the mechanical performance of a component is challenging because material should be designed at the same time as the component.

Simcenter 3D for predictive engineering

Simcenter 3D for composites from Siemens PLM Software provides a complete set of features dedicated to composite simulation that allow you to lead the virtual design process so you can develop robust lightweight composite structures.

Simcenter 3D, which is part of the Simcenter™ portfolio, extends the boundaries of the classic finite element analysis (FEA) method so you can study the structural and highly nonlinear behavior of composite materials. The platform can be used to cover motion analysis for a component made with composites and/or the noise, vibration and harshness (NVH) of composites in the same working environment. The main objective is to help you increase structural efficiency and reliability while minimizing weight.



Powerful modeling tools

The Simcenter 3D for composites solution includes:

- A structural analysis solution with embedded computer-aided engineering (CAE) process management that is integrated with world class data management and tracking tools
- Computer-aided design (CAD)/CAE that is integrated with geometry editing for the CAE engineer
- An open and scalable environment that allows you to customize and automate your simulation process
- Multidiscipline integration (multiphysics, multi solver)
- An environment that is well suited to support the full composite workflow in a multi finite element solver setting
- Capabilities that support the complete simulation design process

Lightweight design with multi-scale optimization

Lightweight design is synonymous with composites, so finding the optimum configuration of your composite structure (ply thickness, ply orientation, stacking sequence, etc.) can require several optimization procedures such as structural design improvement and sizing (minimize thickness, hence weight); generation of feasible designs from infeasible designs (original model violates stress levels); correlation (model matching to produce similar response, frequency response, modal test) and sensitivity evaluation (identifies which regions of the model are most sensitive to design changes and imperfections).

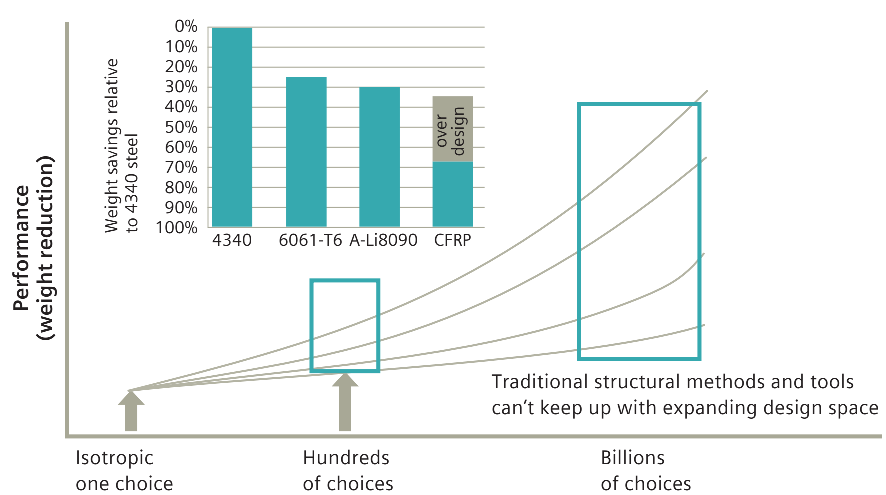
The HEEDS™ software design space exploration solution addresses business needs by streamlining the preliminary sizing process for composite component designs using four key enablers:

- Process automation – Automate driving changes to zonal ply layups to meet performance requirements for one or more parts, analysis tools or departments
- Distributed execution – Leverage all hardware platforms to speed up run times
- Efficient search – Use the robust search engine to find better performing design configurations in less time
- Insight and discovery – Gain deeper understanding about how the key characteristics impact performance, design robustness and sensitivity

A key challenge in composites sizing is the vast number of parameters that can be changed. Knowing what to change and by how much is difficult. Using HEEDS enables you to handle changing a large number of parameters with ease.

Using HEEDS also enables others to leverage the models developed by analysts to explore the impact of design changes and search for better performing solutions to meet requirements.

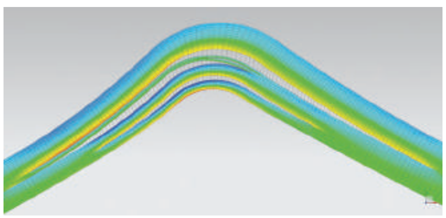
Expanding design space due to combining a number of properties of composite materials



Material combinations, ply orientations, manufacturing techniques.

Exploit the full potential of composite materials

Simcenter 3D fully supports the traditional first-ply-failure approach of simulating the behavior of continuous fiber laminated structures. With Simcenter 3D, engineers can also investigate structural behavior beyond first-ply failure and predict impact effects, determine sensitivity to the structural defects and simulate damage propagation under in-service loads. In addition, this stiffness degradation can serve to predict the fatigue life of your structure.



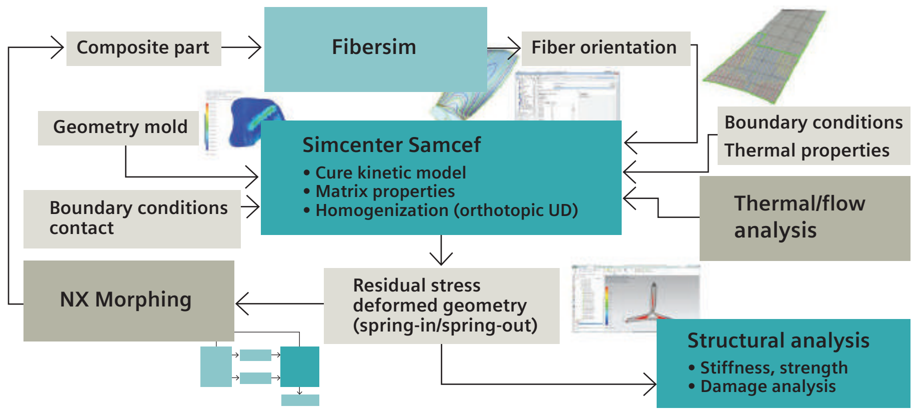
Fatigue-life prediction

Using Simcenter 3D enables you to predict the fatigue life of your structure in short fiber or continuous fiber. The critical step in developing an accurate prediction is to reproduce the loading conditions undergone by the composite component. In different applications, the challenge is related to the variability of those conditions: multi-axial and variable amplitude on long duration fatigue loading. This is why Siemens PLM Software has developed an innovative composite fatigue CAE methodology that keeps track of material degradation under such conditions.

NVH with composites

From the NVH perspective, the most important issue is the high strength-to-weight ratio of composite materials. Although this property is helpful in reducing weight and achieving frequency targets, it harms the transmissibility and component durability and/or comfort. Using Simcenter 3D NVH enables you to design in the same way as you would with a conventional metal component while realizing the same quality of results.

Manufacturing process overview
Siemens simulation capabilities



Simulating the manufacturing process

Curing thermoset materials induces undesirable deformations that require iterations in the manufacturing process. By combining robust thermal and structural analysis technologies, Simcenter 3D offers best-in-class thermochemical and thermomechanical capabilities to predict the residual strain from the curing cycle. This allows you to optimize your process, comparing different manufacturing options for the curing cycle and the mold design.

Features

Engineering desktop

- Easy on-the-fly editing of geometry
- Fast and accurate mid-surfacing toolbox
- Efficiently create, connect and manage composite FE assemblies
- Common environment for multi CAE solver support
- Powerful customization and automation tools
- Leverage geometry associativity when required

Laminate composites

- Ply, zone and mixed modeling approaches
- 2D, 3D and mixed models
- Laminates management, optimization and validation
- Generation of advanced composite material
- Unidirectional and woven plies, sandwich construction
- Interface with composite design products and multiple finite element solvers
- Dedicated and productive postprocessing set of tools

Analysis

- Structural
  - Comprehensive finite element library for 2D shell or 3D solids, cohesive zone modeling
  - Orthotropic, anisotropic, bilinear, progressive damage materials
  - Failure indices, strength ratios, usual finite element outputs
  - Advanced and efficient transient kinematic solutions
  - Accurate progressive damage prediction including intra and interlaminar damage with coupling of the corresponding damage

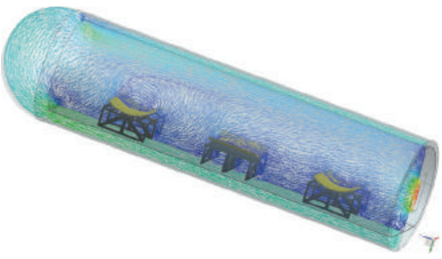
Durability

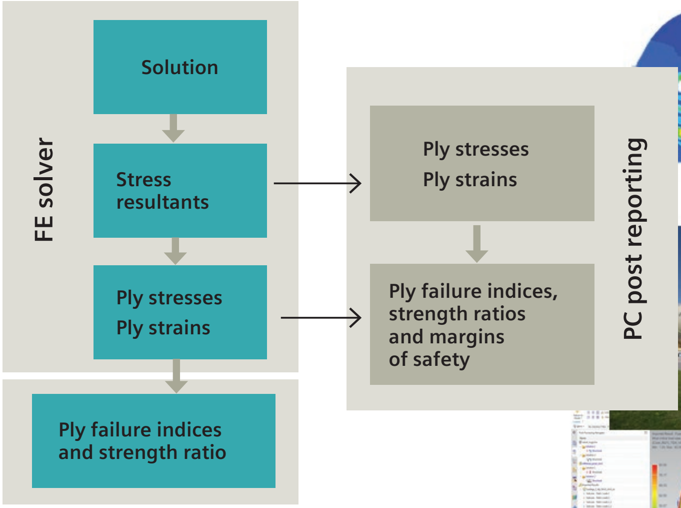
- Short fiber composite fatigue
  - Accurate fatigue analysis using local material behavior
- Multi-axial loading via critical plane
  - Long fiber
- Based on continuum damage analysis
- High-cycle fatigue
- Variable amplitude

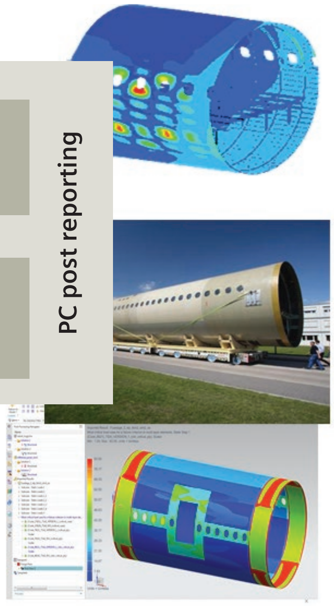
- NVH
  - Dedicated workflow support
  - Complete postprocessing
  - Damping properties
  - Acoustic cavity meshing algorithms
- Thermal/flow, multiphysics
  - Coupled structural-thermal solutions
  - Conductive, convective and radiative heat transfer of multilayer 2D and 3D models
  - Through-thickness temperature gradients
  - Thermal-structural model mapping
  - Thermoelastic distortion simulation
- Design exploration
  - Tradeoff, correlation, sensitivity analysis
  - Handling of large sets or parameters
  - Process automation, scalable computation
- Manufacturing simulation
  - Curing simulation of thermoset material
  - Spring back evaluation
- Data management
  - Material
  - Manufacturing process
  - Simulation data management

Evolving design process

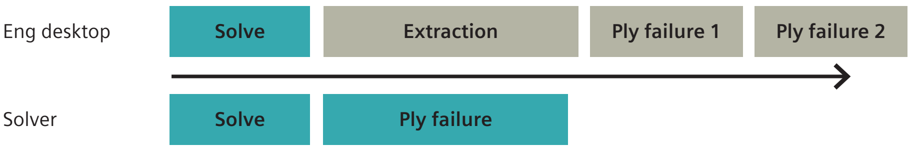
The Simcenter 3D solution for composites is at the leading edge of composites simulation because we are continuously developing new material models and simulation capabilities. Using the Simcenter 3D solution for composites enables you to speed the entire virtual design process by simulating laminate composite materials through a seamless connection to composites design and solvers, providing a comprehensive framework.







Example on 1.2 M elements and nodes with seven loads cases
Three failures critieria and envelope for critical plies and load case



Composites provide the potential for innovation, yet they are complex materials and every company has to evolve their design process to accommodate them. The technical foundation of Simcenter makes it possible for us to provide a solution that can deal with the intricacies of this type of material.

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