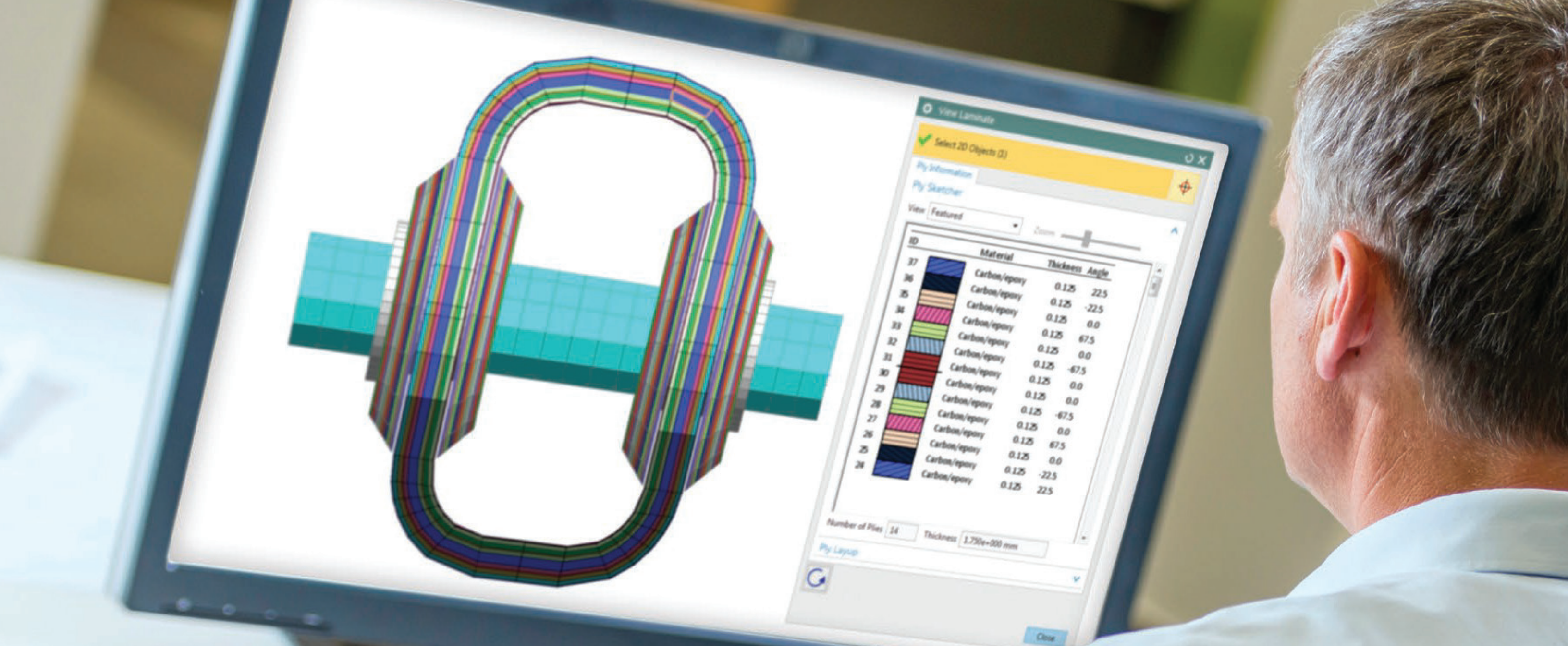


SIEMENS DIGITAL INDUSTRIES SOFTWARE

Simcenter 3D for materials engineering

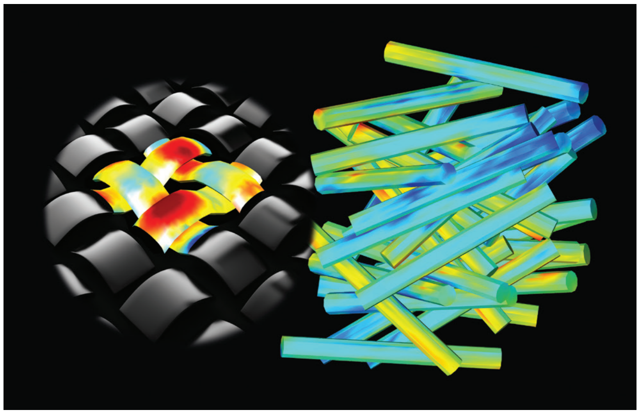
Increasing confidence in developing advanced materials and enhancing their product performance

Solution benefits

- Reduce time and cost to market by simulating new material designs and eliminating poor iterations earlier in the development process
- Optimize new material designs for the most cost-efficient performance
- Gain insight into how, when and why damage to the microstructure will occur and how it will impact the global part
- Use new materials to achieve weight reduction targets while providing safe and durable structures
- Learn how the manufacturing process will affect the material microstructure and overall part performance
- Account for material variability and defects using high-fidelity simulation models

Using homogenized material properties is not enough when considering new materials like foams and composites or new manufacturing techniques like additive manufacturing and automatic fiber placement. Simcenter™ 3D software, which is part of the Xcelerator™ portfolio, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software, helps you accelerate the product development lifecycle of materials by accurately accounting for microstructural details, defects and manufacturing-induced variations, as well as predicting behavior in advanced materials.

It enables manufacturers to implement advanced materials into their designs and make their products lighter, stronger and more durable. Simcenter 3D provides a complete set of features and digital



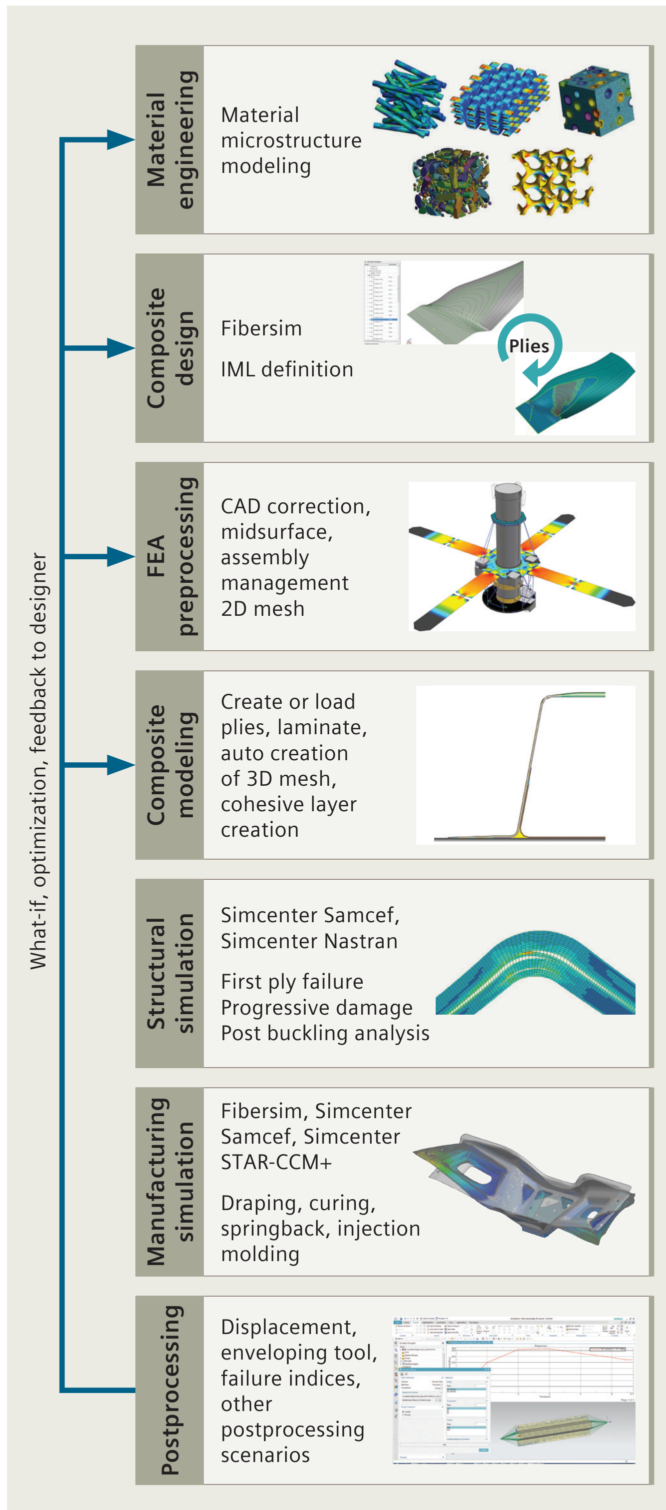
Simcenter 3D for materials engineering

workflows for multiscale modeling and simulation capabilities to help you identify behavior and the root cause of failure in advanced materials, literally zooming into the material's microstructure. It is used by companies working with novel materials to reduce development time and costs by virtually testing how behavior, and then damage at the microstructure, can lead to part failure and learning how controllable manufacturing conditions can ultimately lead to improved performance. Using Simcenter 3D also helps you streamline the simulation process of structures made from laminate composite materials.

Facilitating microstructural modeling and materials engineering

Advanced materials often behave in ways that are difficult to predict, resulting in longer time and higher cost to bring new products to market. These materials are difficult to predict because of heterogeneity at the microstructural level. Simcenter 3D offers solutions for materials engineering that can help predict behavior for these materials at a microstructural level. Simcenter 3D Materials Engineering consists of a unique multiscale finite element (FE) software platform that extends the flexibility and robustness of the finite element method (FEM) down to the microstructural level, strongly coupling the part (macro) and material (micro) length scales and naturally embedding microstructural design variables into the design process; thus giving materials true degrees-of-freedom (DOF). Along with this multiscale technology, Simcenter 3D includes many features that help facilitate the microstructural modeling and materials engineering process. It enables you to:

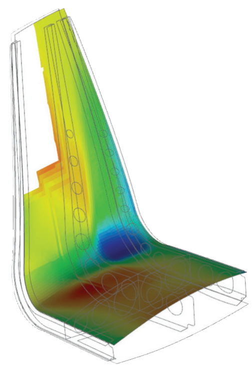
- Zoom into the material microstructure to obtain key insight into the material behavior, identify the root cause of failure and see what damage mechanisms play the most significant roles in structural performance
- Account for manufacturing variability and imperfections to maximize product reliability
- Optimize the material microstructure for the most cost-efficient performance
- Virtually create and test new and existing materials



Materials engineering simulation workflow.

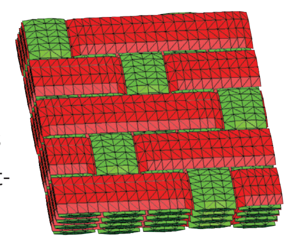
Supporting the modeling process for laminate composites

From material design to component design, Simcenter 3D delivers a powerful toolset for modeling continuous fiber laminate composite structures. A seamless connection with the Fibersim™ portfolio facilitates the transfer of the initial composite design into Simcenter 3D. Then easy-to-use ply and laminate definition tools in Simcenter 3D enable you to quickly create FE models in 2D and 3D representing your design, and helps you optimize and validate composite structures using your preferred solver.



In addition to modeling, Simcenter 3D can help you validate your draping simulation to help you understand how the fibers will be oriented on your part.

At the microstructure level, the Simcenter 3D user interface allows you to easily generate a wide range of customized microstructure models automati-cally. This includes automatically creating or importing microstructure geometries and meshes, creating and assigning material models for individual constituents and interfaces, quickly and easily setting up material virtual tests, coupling with optimization tools and launching fully coupled concurrent multiscale analyses.

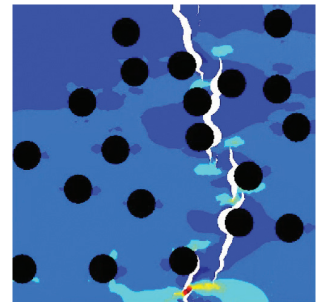


Simcenter 3D offers the industry's most comprehensive set of simulation capabilities for composite design with faster and more efficient workflows to enable a concurrent process and extensive analysis-type coverage to support standard verifications approaches. It allows you to also address niche solutions that are unique to composite simulation challenges like durability and highly nonlinear effects like manufacturing simulation or progressive damage via a variety of modeling approaches, including stiffness reduction, element deletion, continuum damage models or automatic insertion of cracks or cohesive zone elements.

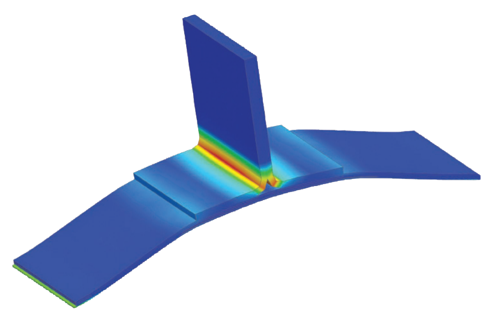
Simcenter 3D offers specific capabilities that are mandatory for the successful development of composites from the material design to the full component design.

Powerful solvers

Simcenter 3D provides powerful solvers for simulating structural and manufacturing performance of parts made from laminate composite materials and for simulation of models using advanced materials at the microstructural level.



The Simcenter Multimech™ platform is a nonlinear finite element solver capable of performing two-way coupled, multiscale analyses of parts, as well as streamlined virtual testing of material microstructural models. Simcenter Multimech multiscale solver technology provides unprecedented speed without sacrificing accuracy by combining two breakthrough innovations – a new mathematical formulation and an adaptive multiscale algorithm. Additionally, it is fully parallelized across threads and central processing unit (CPU) cores to achieve even greater gains in performance. Simcenter Multimech can also be coupled with Simcenter Nastran® and Simcenter Samcef® software as well as third-party FE solvers.



Using Simcenter Samcef® software enables the user to simulate components made of composite materials. It facilitates not only classical linear and nonlinear analysis but can be used to predict manufacturing-induced defects as they grow, including intra- and interlaminate defects. This includes delamination and complex scenarios in which both defect types grow together in a fully coupled way. Other manufacturing-induced effects covered by this solver are part distortion, both during the additive manufacturing build-process and during thermoset composites curing.

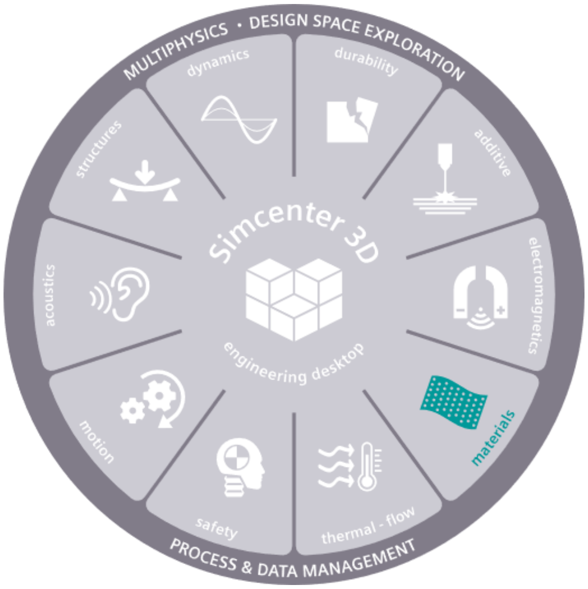
Open for leveraging third-party solvers

Take advantage of the unique and fast modeling and postprocessing capabilities of Simcenter 3D and use them in connection with investments in other popular FE solvers. Simcenter Multimech can be run with the Abaqus and Ansys solvers for fully coupled multiscale analysis. Other features like de-homogenization, mapping fiber orientation data and defect insertion are also available.

You can also create laminate composite-based FE models in Simcenter 3D for use with Simcenter Nastran, Abaqus, Ansys or MSC Nastran solvers. The results from these solvers can be read back into Simcenter 3D for postprocessing and evaluating results.

Providing a platform for multidiscipline simulation

The Simcenter 3D solutions for materials engineering are part of a larger, integrated multidiscipline simulation environment with Simcenter 3D Engineering Desktop at the core for centralized pre-/postprocessing for all Simcenter 3D solutions. This integrated environment helps you to achieve faster computer-aided engineering (CAE) processes and streamline multidiscipline simulations such as motion analysis and/or the noise, vibration and harshness (NVH) analysis of composite components. You can also validate your structure's fatigue life using Simcenter 3D durability modules and validate your FE model with test results using correlation and model updating tools.

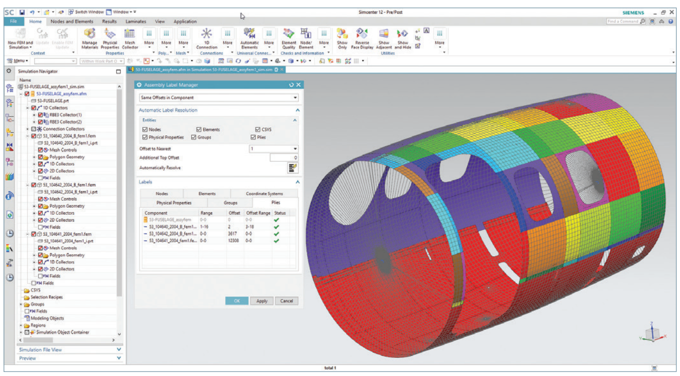


Industry applications

Simcenter 3D supports applications across multiple industries where companies are investigating advanced materials to improve product performance and cost effectiveness.

Aerospace and defense

- Nonlinear deformation and failure analysis of composite structures like wing spars and fuselage ribs
- Accurate fully coupled sub-modeling and multiscale capabilities to analyze the general aircraft and individual components
- Facilitation of virtual material certification of advanced materials
- Simulate distortion from manufacturing processes, like additive manufacturing or curing



Automotive and transportation

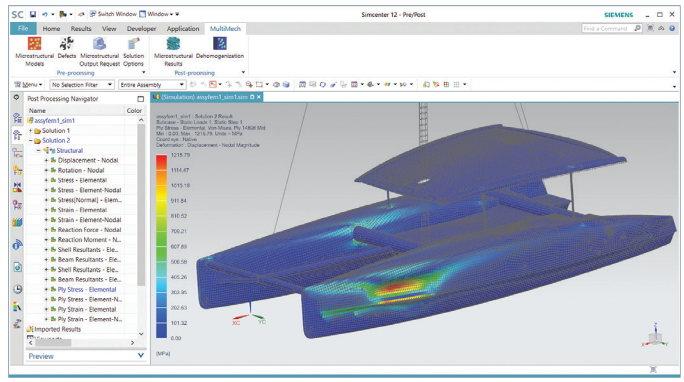
- Structural performance of body and chassis components made from laminate composite materials
- Noise, vibration, and harshness analysis of composite materials for primary structures like the chassis
- Curing simulation for laminate composite components

Material and chemical

- Minimize the number of physical tests required to develop and certify new materials
- Virtually test materials to better understand microscale mechanisms that drive material performance and gain insights using simulation results not obtainable via physical testing
- Optimize materials to achieve customer-specific performance requirements
- Increase adoption of advanced materials by enabling materials end users to leverage simulation in their product design process

Marine

- Manufacturing process simulation for glass fiber composites for hulls
- Bolt bearing and delamination analysis for composite joints



Consumer goods

- Durability and stiffness of heterogenous materials for packaging
- Composite analysis for fiber wound golf shafts, energy absorbing protective equipment and other recreational applications

Electronics

- Thermal cracking, cycling and fatigue for electronic assemblies
- Drop tests for hand-held devices
- Overcome issues in directly modeling small micro and nanostructures

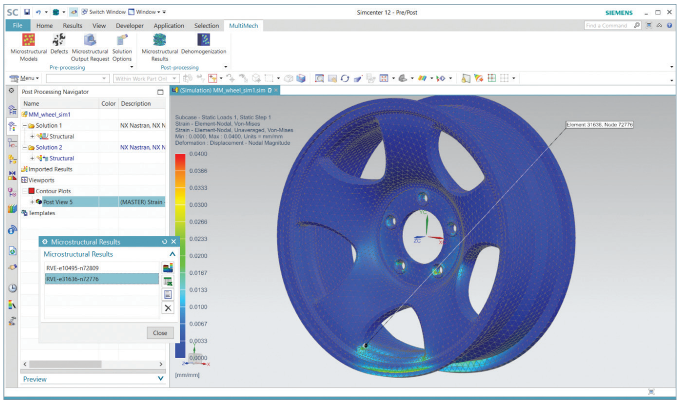
Energy

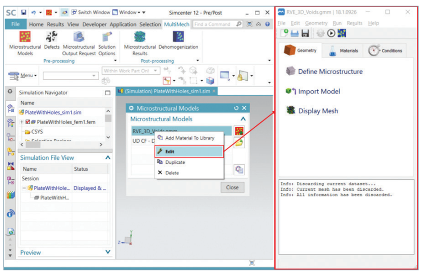
- Analysis of composite risers for oil and gas exploration
- Prediction of burst pressure of continuous fiber reinforced tubes and pressure vessels, including the effect of defects
- Analysis of fiber reinforced wind turbine blades

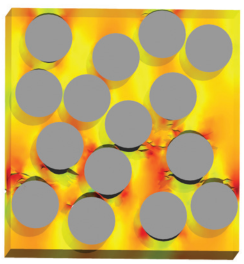
Simcenter 3D
Materials Engineering Standard

Simcenter 3D Materials Engineering Standard allows you to perform multiscale modeling and simulate failure in advanced materials directly within the Simcenter 3D environment. Using Simcenter 3D Materials Engineering, you can identify when, where, how and why a material may fail at the micro-structural level, and how this will affect the performance of the overall part.

Simcenter 3D Materials Engineering Standard comes with a full suite of tools to enable you to accurately model and simulate the performance of your advanced materials using true multiscale technology. Users can also leverage its capabilities in additive manufacturing workflows to account for the effect of microstructural features such as defects, metal grain morphologies and grain boundaries, as well as homogenization and optimization of lattice structures.







Module benefits

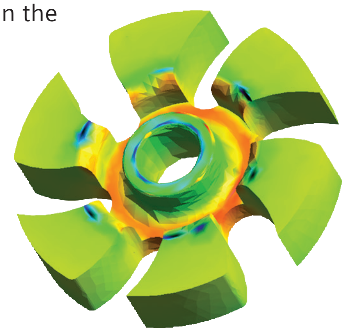
- Optimize performance of advanced materials before a physical sample is built
- Reduce number of physical iterations required to test and certify new materials
- Gain valuable insight into how microstructural behavior will impact part or system performance
- Account for microstructural details, including defects and manufacturing-induced variations in the design process
- Optimize materials to achieve customer-specific performance requirements

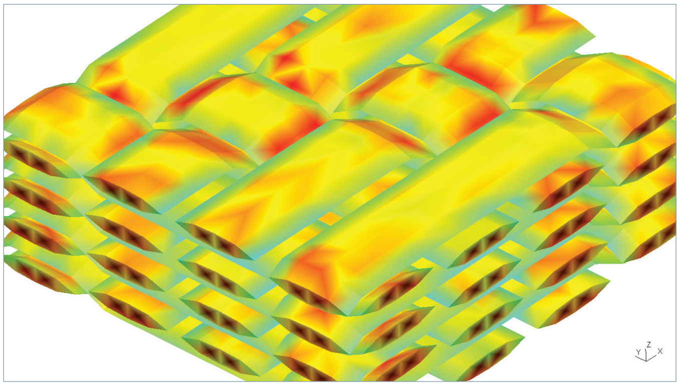
Key features

- Automatic microstructure generation tool to generate geometry and meshing of your microstructural models for a wide range of materials, including continuous fiber, chopped fiber, particulates, voids, (stacked) fabrics, combinations of different inclusions, laminates and more, as well as import from third-party tools
- Perform multiscale, material virtual testing and de-homogenization simulations
- Analytical homogenization methods for simpler analyses
- Postprocessing of multiscale results, including concurrent visualization of part and full-field results from microstructural models
- Reverse engineering of material parameters
- Enable multiscale modeling in Simcenter Nastran (solution 401/402) and Simcenter Samcef. Simcenter Nastran and Simcenter Samcef can be purchased separately
- Up to two parallel threads/cores in Simcenter Multimech. High performance computing (HPC) add-on can be purchased, with each add-on enabling four additional parallel threads/cores in Simcenter Multimech

Simcenter 3D
Materials Engineering Advanced

Simcenter 3D Materials Engineering Advanced allows you to perform multiscale modeling and simulate failure in advanced materials directly in the Simcenter 3D environment. This module builds on the capabilities delivered by Simcenter 3D Materials Engineering Standard and adds advanced capabilities for automatic defect workflows and the ability to interface with CT scanning software.





Module benefits

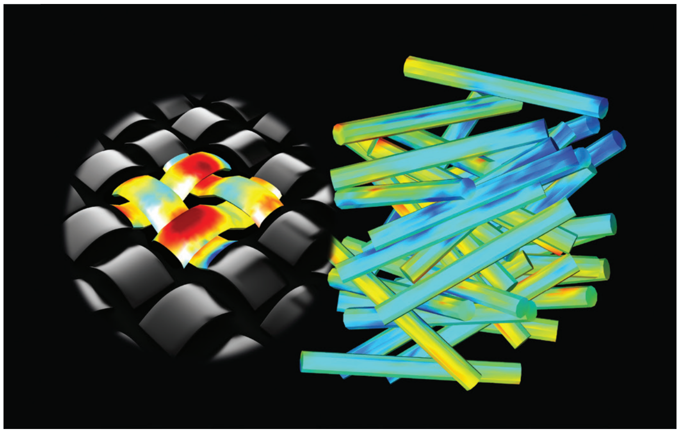
- Simplify modeling process for defects and variations in material microstructures
- Quickly convert CT scans of physical parts into microscale material models
- Get results quicker through high performance computing
- Design injection molded parts accounting for material microstructure and manufacturing induced variations

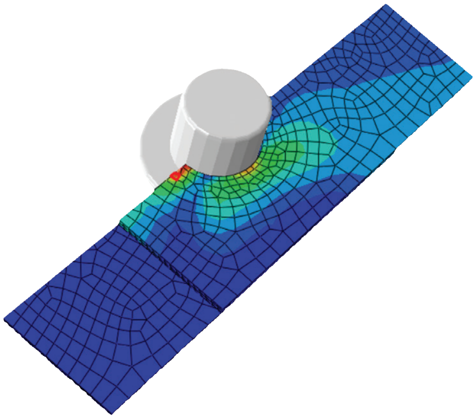
Key features

- Simcenter 3D Materials Engineering Standard is a prerequisite
- The injection molding interface data mapper tool allows manufacturing process simulation results (including Fibersim, Moldflow and Moldex3D) to be mapped onto a structural mesh
- Interface with VoxTex software used for analysis of micro-computed X-ray tomography images and their transformation into finite element models
- Automatic defect insertion workflows
- Includes one HPC add-on for four additional parallel threads/ cores in Simcenter Multimech. More HPC add-ons can be purchased

Simcenter Multitech

Simcenter Multimech is an advanced nonlinear finite element solver for materials modeling, capable of performing two-way coupled true multiscale analyses of parts, as well as streamlined virtual testing of material microstructural models. It empowers the multiscale solutions available in Simcenter 3D Materials Engineering platform and is also included as part of plugins for Ansys and Abaqus.





Module benefits

- Optimize performance of advanced materials before a physical sample is built
- Reduce number of physical iterations required to test and certify new materials
- Gain valuable insight into how microstructural behavior will impact part or system performance
- Account for microstructural details, including defects and manufacturing induced variations in the design process
- Optimize materials to achieve customer-specific performance requirements

Key features

- Advanced nonlinear finite element solver, including mechanical (quasi-static implicit and dynamic explicit), thermal diffusion and coupled thermomechanical analysis, with a rich library of material models and element types
- Perform multiscale, material virtual testing and de-homogenization simulations, using implicit or explicit FEA
- In addition to standalone simulation jobs, Simcenter Multimech can be coupled with other FE solvers for concurrent multiscale analyses, including Simcenter Nastran, Simcenter Samcef, Ansys and Abaqus
- Progressive failure modeling capabilities, including stiffness reduction, element deletion, continuum damage and a unique algorithm for automatic insertion of 2D/3D cracks or cohesive zones, with automatic correction of interpenetrating interface elements
- Stochastic failure modeling via statistical distribution of failure parameters
- Simulate curing and induced residual stresses at the material microstructural level
- Up to two parallel threads/cores. HPC add-ons can be purchased, with each add-on enabling four additional parallel threads/cores

Simcenter Multitech
HPC Add-on

The Simcenter Multimech HPC Add-on increases the number of parallel threads/cores the Simcenter Multimech solver can use for computation. The base solver supports up to two parallel threads/cores, and each HPC add-on module adds four additional parallel threads/cores that can be used.

Module benefits

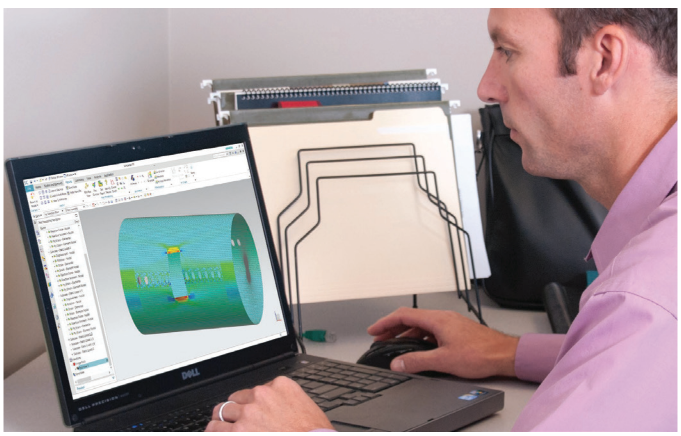
- Expands the number of parallel threads/cores used for computation so that you can solve larger, more complex models faster

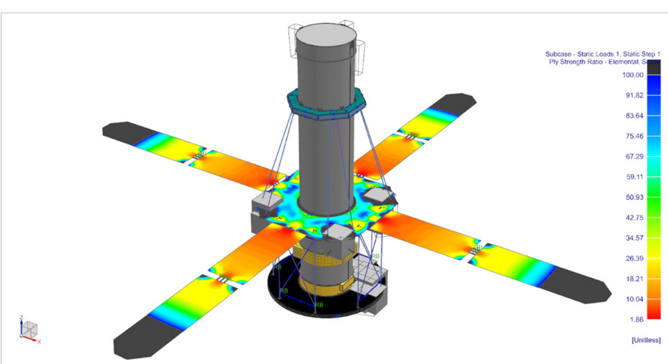
Key features

- Adds up to four parallel threads/cores for each add-on module

Simcenter 3D Laminate Composites

Simcenter 3D Laminate Composites features easy-to-use ply and laminate definition tools which help you create and validate composite structure models. You can use Simcenter 3D Laminate Composites to prepare models for the Simcenter Nastran, Simcenter Samcef, MSC Nastran, Ansys, Abaqus, or LS-Dyna solvers. Laminate post reporting processes solver stresses or shell resultants to generate contour and tabular results, including envelopes of ply stresses, strains and failure metrics over multiple load cases.



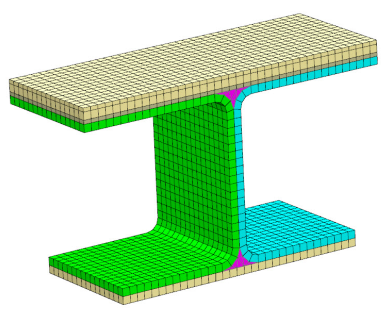


Module benefits

- Reduce laminate model creation time by choosing between zone-based modeling, ply-based modeling or a mixture of both approaches
- Leverage the open solver architecture of Simcenter 3D to perform state-of-the-art dynamic, nonlinear, progressive failure and delamination simulations

Key features

- Define laminates on 2D meshes, 3D meshes or both
- Keep your model up-to-date with the latest design using geometry associativity
- Interact with computer-aided design (CAD) based composites definitions from Fibersim, CATIA and others
- Use Simcenter standard materials, or create ply materials from the constituent fiber and matrix material properties, to simulate plies made of woven, unidirectional, randomly oriented short fibers and particulates and represent cores
- Conveniently assign laminates and plies to your choice of geometry, meshes and/or elements
- Improve finite element modeling accuracy by accounting for distorted fiber orientations
- Postprocessing tools allow you to quickly identify critical plies and load cases using classical and user-defined failure theories and create reports



Simcenter Samcef

Simcenter Samcef is used as a solver to simulate components made of composites and additive manufacturing materials. It facilitates not only classical linear and nonlinear analysis, but can be used to predict defects, including intra- and interlaminate defects, as they grow. This includes delamination and complex scenarios in which both types of defect grow simultaneously.

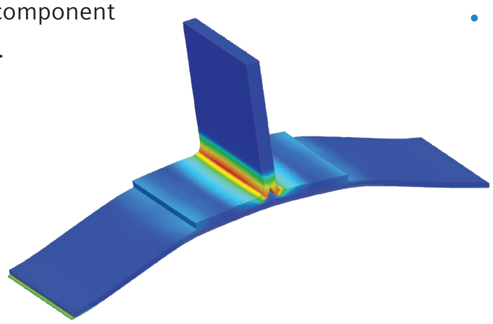
Curing of thermoset materials induces undesirable deformations that require iterations in the manufacturing process. By combining robust thermal and structural analysis technologies, Simcenter Samcef offers thermal, chemical and mechanical capabilities to predict the residual strain from the curing cycle. This allows you to optimize your process, comparing manufacturing options for the curing cycle and the design, and applying mold compensation techniques to minimize spring back effects at demolding. It is then possible to simulate as-built composite component rather than as-designed.

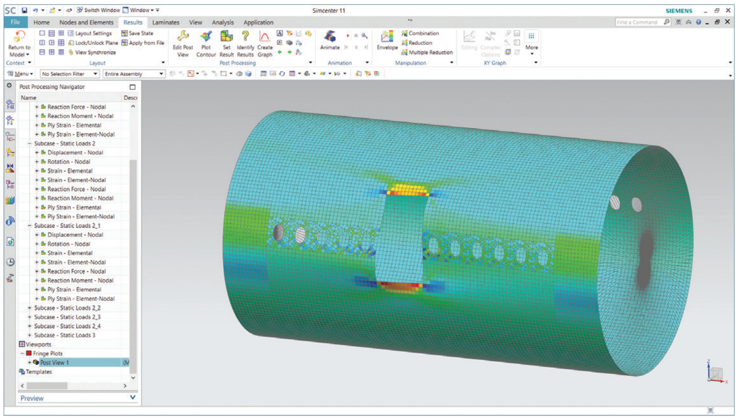
Module benefits

- Achieve weight reduction targets and provide safe, durable structures
- Design as manufactured and for manufacturability
- Capture and identify the behavior of layered composite components, reducing safety concerns
- Identify and optimize unexpected deformation during the additive manufacturing process and during curing cycle

Key features

- Static/dynamic/thermal analysis of composite models including material and geometrical nonlinear behaviors
- Comprehensive finite element library for 2D shell or 3D solids, cohesive zone modeling
- Orthotropic, anisotropic, bilinear, accurate progressive damage prediction including intra- and interlaminar damage with coupling of the corresponding damage
- Failure indices, strength ratios, usual finite element outputs





Pre/post capabilities for materials engineering simulation

General capabilities	Specific capabilities	Simcenter 3D Laminate Composites	Simcenter 3D Materials Engineering Standard	Simcenter 3D Materials Engineering Advanced
Automatic microstructure generation				
Continuous fibers (hex pack, square pack, random pack)			•	
Short fibers			•	
Particulates, shells			•	
Voids/porosity			•	
Fabrics/woven (stacked)			•	
Laminates		•	•	
Combination of different inclusions			•	
Coating			•	
Multiscale analysis				
True multiscale (con-current, 2-way coupled, 2+ scales)			•	
Homogenization	Analytical	•	•	
	Numerical		•	
Dehomogenization			•	
Material virtual testing and Parameter Identification			•	
Postprocessing of microstructural cracks			•	
Integrations				
Third-party software	Ansys	•	•	
	Abaqus	•	•	
	MSC Nastran	•		
	LS-Dyna	•		
	Catia Composite Design	•		
	WiseTex		•	
	VoxTex			•
	TexMind		•	
	TexComp		•	
	TexGen		•	
Siemens software	Simcenter Nastran	•	•	
	Simcenter Samcef	•	•	
	Simcenter HEEDS	•	•	
	Fibersim	•	•	

General capabilities	Specific capabilities	Simcenter 3D Laminate Composites	Simcenter 3D Materials Engineering Standard	Simcenter 3D Materials Engineering Advanced
Laminate modeling				
Laminate modeling and validation	Ply-based modeling	•		
	Zone-based modeling	•		
	2D laminates (layered shell)	•		
	3D laminates (layered 3D solids) including automatic 3D inflation	•		
	Automatic generation of cohesive layers	•		
	Drop off element			
	Anisotropic behavior of sheared woven plies	•		
	ABDS matrices and equiva-lent properties	•		
	Fiber orientation displays	•		
	Ply section displays	•		
	View laminate core sampling	•		
CAD Interfaces	Fibersim	•		
	CATIA/laminate tools	•		
Postprocessing and reporting	Graphical and spreadsheet reporting	•		
	Enveloping by ply and load case	•		
	Management of post reports and prerequisite solutions	•		
	Classical and user-defined failure theories	•		
	Multiple failure theories in single report	•		
	Ply failure indices, strength ratios and margins of safety	•		
	Dynamic base excitation metasolutions	•		
	Harmonic with phase-con-sistent failure metrics	•		
	Random with confi-dence-based peak failure metrics	•		

General capabilities	Specific capabilities	Simcenter 3D Laminate Composites	Simcenter 3D Materials Engineering Standard	Simcenter 3D Materials Engineering Advanced
Manufacturing induced variations				
Defects workflow				•
Injection molding workflow				•
	Autodesk Moldflow interface			•
	Moldex3D interface			•
Import of micro-CT scan voxel mesh				•
Data mapper				•

Notes:

- Simcenter 3D Engineering Desktop is a minimum prerequisite for all Simcenter 3D products.
- Simcenter 3D Materials Engineering Standard includes Simcenter Multimech solver base package
- Simcenter 3D Materials Engineering Advanced requires Simcenter Materials Engineering Standard
- Simcenter 3D Materials Engineering Advanced includes 1 x Simcenter Multimech HPC Add-on

Solver capabilities for materials engineering simulation

General capabilities	Specific capabilities	Simcenter Samcef Solver	Simcenter Multimech
Multiscale analysis			
True multiscale (concur-rent,two-way coupled, two+ scales)		•	•
Numerical homogenization, dehomogenization and virtual material testing			•
Analysis			
Implicit linear and nonlinear quasi-static		•	•
Explicit linear and nonlinear dynamic			•
Thermal analysis (steady state or transient)		•	•
Coupled thermomechanical		•	•
Modal analysis		•	
Buckling analysis (form linear statics analysis) with several load cases		•	
Finite deformation		•	•
Finite deformation - Total lagrangian		•	•
Standalone bucking		•	
Mapping of temperature field/glass temperature/ degree of cure		•	
Superelement generation, recovery on superelement		•	

General capabilities	Specific capabilities	Simcenter Samcef Solver	Simcenter Multimech
Cyclic symmetry recombination		•	
Auto-time stepping		•	•
Shared memory parallel (SMP)		•	•
Distributed memory paralled (DMP)		•	•
Superelements		•	
Superelements - recovery including stresses		•	
Cyclic symmetry modes		•	
Multi-stage cyclic symmetry		•	
Harmonic modes		○	
Restart		•	
Materials			
Elasticity	Isotropic linear thermoelastic	•	•
	Orthotropic linear thermoelastic	•	•
	Anisotropic linear thermoelastic	•	
	Temperature dependence of elastic properties	•	•
	Isotropic tabular/multilinear thermoelastic	•	•
	Isotropic linear elastic with bi-modulus	•	•
	Orthotropic nonlinear elastic with bi-modulus		•

General capabilities	Specific capabilities	Simcenter Samcef Solver	Simcenter Multimech
Viscoelasticity	Isotropic linear thermo-visco-elastic with aging	•	•
	Isotropic continuum damage thermo-viscoelastic with aging		•
	Anisotropic linear thermo-visco-elastic with aging		•
Elastoplasticity	Isotropic Von Mises thermo-elastoplastic		•
	Isotropic Drucker Prager thermo-elastoplastic		•
	Temperature dependence	•	
	Bilinear	•	
	Multilinear	•	
	Rupture	•	•
	Isotropic hardening	•	•
	Kinematic hardening	•	•
	Mixed hardening	•	•
	Strain rate effect	○	
Elasto-viscoplasticity	Isotropic Von Mises thermo-elastoviscoplastic	•	•
Continuum damage	Isotropic continuum damage thermoelastic		•
	Orthotropic continuum damage thermoelastic		•
	Isotropic continuum damage thermo-viscoelastic with aging		•
	Isotropic continuum damage elastic with bi-modulus		•
	Orthotropic continuum damage elastic with bi-modulus		•
Cohesive zone models	Linear decay		•
	Bilinear	•	•
	Bilinear rate dependent		•
	Tvergaard		•
	Allen nonlinear viscoelastic		•
	Material interface (automatic crack/cohesive zone insertion)		•
Multiscale material models	Microscale RVE		•
	Microscale cohesive zone RVE		•
Diffusion models	Isotropic Fourier		•
	Isotropic Fourier (thermo active)		•
Hyperelastic			•
	Moony-Rivlin	•	
	Arruda- Boyce	○	
	Ogden	•	
	Foam	•	
	Hart-Smith	○	

General capabilities	Specific capabilities	Simcenter Samcef Solver	Simcenter Multimech
Hyperelastic *(continued)*	Alexander	○	
	Marlow	○	
	Test based	○	
	Mullins effect	•	
	Viscoelastic effect	○	
	Gasket	○	
	Creep		
	Bailey Norton model	•	
	Strain hardening power model	•	
	Norton model	○	
	Garafolo model	○	
	Temperature dependent	•	
	User defined	○	
Failure modeling			
Failure index (various failure envelopes)			•
Stiffness reduction			•
Element deletion			•
Continuum damage			•
Automatic insertion of 2D/3D cracks and cohesive zones			•
Automatic correction of interpenetrating interface elements			•
Multiscale damage upscaling			•
Stochastic failure			•
Elements			
3D solids	4-node tetrahedron	•	•
	10-node tetrahedon	•	•
	8-node hexagon	•	•
	20-node hexagon	•	•
	8-node hexagon infinite	•	•
	12-node hexagon infinite	•	•
	8-node quadrilateral interface	•	•
	16-node quadrilateral interface	•	•
	6-node triangle interface	•	•
	12-node triangle interface	•	•
	2-node line	•	•
	3-node line	•	•
	5-node pyramid	•	•
	13-node pyramid	•	•

General capabilities	Specific capabilities	Simcenter Samcef Solver	Simcenter Multimech
3D solids *(continued)*	6-node wedge	•	•
	15-node wedge	•	•
2D solids	Axisymmetric	•	•
	Plane stress	•	•
	Plane strain	•	•
	Generalized plane strain	◦	•
	3-node triangle	•	•
	6-node triangle	•	•
	4-node quadrilateral	•	•
	8-node quadrilateral	•	•
	4-node quadrilateral infinite	•	•
	5-node quadrilateral infinite	•	•
	4-node line interface	•	•
	6-node line interface	•	•
	2-node line	•	•
	3-node line	•	•
Shell		•	
	Thickness output	•	
Membrane		•	
Solid shell		•	
Beam		•	
	Nonlinear effects	•	
Springs		•	
	Nonlinear force displacement	•	
Rods		•	•
Rigid	Large rotation effect	•	
	Stiff rigid (RBE2)	•	
	Constraint rigid (RBE3)	•	
U-P formulations		•	
Potential fluid		◦	
Add/remove		•	•
Laminate modeling			
Laminate modeling and validation	Ply-based modeling	•	
	Zone-based modeling	•	
	2D laminates (layered shell)	•	
	3D laminates (layered 3D solids) including automatic 3D inflation	•	
	Automatic generation of cohesive layers	•	

General capabilities	Specific capabilities	Simcenter Samcef Solver	Simcenter Multimech
Laminate modeling and validation *(continued)*	Drop off element	•	
	Anisotropic behavior of sheared woven plies	•	
	ABDS matrices and equivalent properties	•	
Postprocessing and reporting	Enveloping by ply and load case	•	
	Multiple failure theories in single report	•	
	Ply failure indices, strength ratios and margins of safety	•	
Composite			
Shell elements (mono and multilayers)		•	
Solid elements (mono and multilayers)		•	
Failure indices		•	•
Strength ratios		•	
Cohesive delamination		•	•
Progressive failure		•	•
Non-local laws		•	
Curing simulation		•	•
Connections			
Glue		•	
	Sliding glue	•	
	Large displacement	•	
Bolted joints		•	
	1D	•	
	2D	•	
	3D	•	
	Bolt sequencing by steps	•	
	Bolt force output	•	
Multipoint constraint (MPC)		•	•
Contact	Elastic frictionless		•
	Coulomb friction	•	
	Other friction models	•	
	No separation contact	•	
	Fluid pressure penetration contact		
	Temperature dependence	•	
	Separation distance output	•	
	Slip/slide distance output	•	
	Pressure output	•	

General capabilities	Specific capabilities	Simcenter Samcef Solver	Simcenter Multimech
Contact *(continued)*	Change by steps	◦	
	Node-to-face contact	◦	
	Node-to-node contact	•	•
	Face-to-face contact		•
Kinematic joints		◦	
Loads and boundary conditions			
Mechanical	Prescribed support		•
	Prescribed displacements		•
	Gravity	•	•
	Nodal force	•	•
	Nodal moment	◦	
	Pressure	•	•
	Distributed force	◦	•
	Surface		•
	Volume		•
Temperature	3D (spatial variation)	•	•
	4D (spatial and temporal variation)	•	•
	Temperature loads from external file	•	
Enforced motion		•	
Initial stress/strain	Unbalanced	•	
	Balanced	◦	
Initial damage for composite		•	
Restraints		•	
	Change by steps	•	
Geometry imperfections		•	
Free-volume strain			•

General capabilities	Specific capabilities	Simcenter Samcef Solver	Simcenter Multimech
Microscale boundary conditions	Linear displacements		•
	Periodic displacements		•
	Planar displacements		•
	Uniform tractions		•
Thermal diffusion	Initial temperature	•	•
	Prescribed temperature	•	•
	Heat sources		
	Nodal	•	•
	Surface	•	•
	Volume	•	•
	Surface convection	•	•
	Internal heat source	•	•

Legend:

- • Supported in solver and in the Simcenter 3D environment
- ◦ Means the solver supports this capability, but it is not supported in the Simcenter 3D environment

Notes:

- Simcenter Multimech base package allows executing jobs with up to 2 parallel threads|cores. Additional parallel computing can be enabled by Simcenter Multimech HPC Add-on.
- Each Simcenter Multimech HPC Add-on enables 4 additional parallel threads|cores. Can be sold in multiple quantities, except for node locked licenses, which limits to 1 HPC add-on seat

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