

**SIEMENS**

*Ingenuity for life*

# Simcenter 3D Thermal

## Integrated thermal analysis

### Benefits

- Reduce costly physical prototypes by using thermal simulation to understand product performance
- Shorten modeling time for initial and subsequent design-analysis iterations
- Gain further insight through coupled thermo-fluid multiphysics analysis using Simcenter 3D Thermal with Simcenter 3D Flow
- Understand thermoelastic effects through coupled physics analysis with NX Nastran
- Leverage all the capabilities of the CAD-integrated environment to make quick design changes and provide rapid feedback on thermal performance

### Summary

Simcenter™ 3D Thermal software provides heat transfer solutions and is an add-on module to either Simcenter 3D Engineering Desktop or Simcenter 3D Structures. Simcenter 3D Thermal can simulate conduction, convection and radiation phenomena for complex products and large assemblies. Simcenter 3D Thermal is used to address thermal analysis requirements in a wide range of industries including aerospace and defense, automotive and transportation, consumer products and appliances, energy, medical, electronics and semiconductors. In addition, Simcenter 3D Thermal can also be used with Simcenter 3D Flow, the Simcenter 3D-integrated CFD solution, for coupled thermo-fluid simulation.

### FE-based finite volume thermal solver technology efficiently simulates heat transfer phenomenon

Simcenter 3D Thermal continues Siemens' long heritage in thermal simulation and leverages the same technology that underpinned the I-deas™ TMG solution. Simcenter 3D

Thermal uses high-order finite volume-based technology on a FE mesh to accurately and efficiently simulate heat transfer phenomena. It combines the versatility of FE-based analysis with the accuracy of a finite volume scheme. The Simcenter 3D Thermal solver technology allows simulation of parts and assemblies within complex thermal environments. The solver and modeling features include:

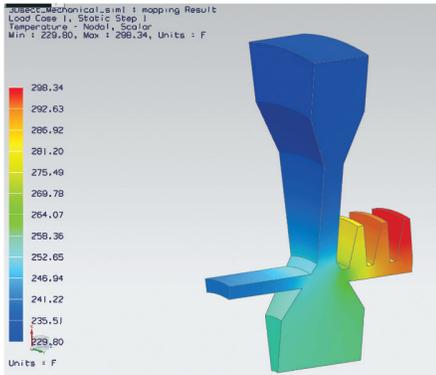
### Solver capabilities

- Steady-state and transient solutions
- Material nonlinear thermal properties
- Axisymmetric modeling
- Iterative conjugate gradient solver technology
- Fully coupled conduction, radiation and convection heat transfer simulation
- 10 choices of consistent units to be used for runtime messages
- Mapping of temperatures to dissimilar structure FE model

### Element types supported in Simcenter 3D Thermal

- 0D concentrated mass
- 1D beam
- 2D triangular and quad thin shell, null shell, uniform and nonuniform multi-layer, linear or parabolic
- 3D linear or parabolic tetrahedral, brick, wedge and pyramid
- Linear and parabolic axisymmetric wedge and brick

# Simcenter 3D Thermal



## Thermal couplings technology for modeling thermal contacts within assemblies

- Thermally connect disjoint and dissimilar mesh faces and edges
- Surface-to-surface, edge-to-edge or edge-to-surface contact modeling between parts: constant, time- or temperature-dependent coefficient of heat transfer, resistance or conductance
- Radiative exchange between disjoint part faces and faces within a single part
- Interface modeling between connected parts: constant, time- or temperature-dependent coefficient of heat transfer, thermal resistance or conductance, edge contact or conductive gap
- Spatially varying heat transfer coefficient can be defined for thermal couplings

## Applied heat loads

- Constant, time and spatially varying heat loads
- Constant, time and spatially varying heat flux
- Constant, time and spatially varying heat generation
- Ability to control all applied loads with temperature-controlled thermostat

## Temperature boundary conditions

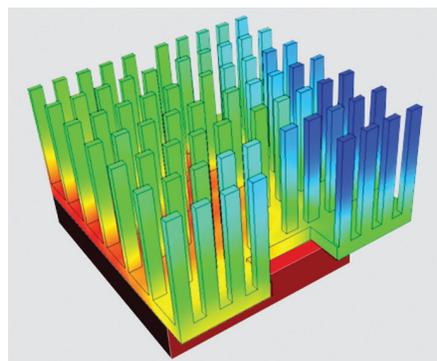
- Constant, time and spatially varying temperature
- Thermostat temperature controllers

## Conduction heat transfer

- Ability to handle large conduction heat transfer models
- Temperature-dependent conductivity
- Temperature-dependent specific heat
- Orthotropic conductivity
- Phase change at temperature or over temperature range

## Convection heat transfer

- Constant, time and spatially varying heat transfer coefficient and environment temperature
- Parameter and nonlinear temperature gradient functions:
  - **Free convection** – Correlation-based free convection to ambient for inclined plates, cylinders and spheres and parallel plate channels
  - **Forced convection** – Correlation-based convection for plates, spheres and cylinders in forced fluid flow



## Radiation heat transfer

- Constant and temperature-dependent emissivity
- Multiple radiation enclosures
- Diffuse view factor calculations with shadowing
- Net view factor calculations
- Adaptive scheme for view factor sum optimization
- Hemicube-based view (form) factors calculation using graphics card hardware
- Radiation patch generation to condense large element-based radiation models
- Radiation matrix controls and parameters

## Initial conditions

- Starting temperatures for both steady-state and transient
- Starting temperatures from previous solution results, from file

## Solver and solution attributes

- Direct access to solver parameters
- Solver convergence criteria and relaxation factors
- Restart conditions, cyclic convergence criteria
- Solver monitor with solution convergence and attributes
- Intermediate results display and recovery directly from solver progress monitor

## Other features

- Result reports:
  - Summary of results to HTML pages and comma separated value (.csv) files compatible with Excel
  - Heat flow calculation between groups
  - Heat maps

- “Track during Solve” reports, to track monitor points and generate a graphical trace during a solution
- Complete or partial deactivation of selected elements (for radiation form factors calculations)
- Temperature mapping for Nastran FE models with dissimilar mesh
- Temperature or capacitance-based non-geometric elements
- Geometry optimization supporting flexible design objectives and variables

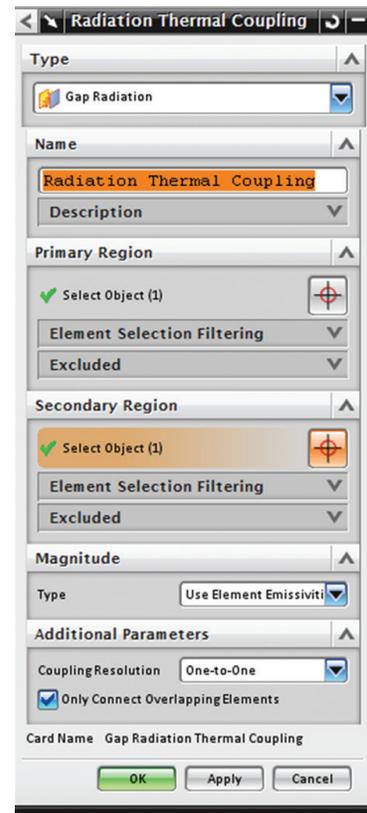
### Simulation results

- Temperatures
- Temperature gradients
- Total loads and fluxes
- Conductive fluxes
- Convective fluxes
- Convection coefficients
- Residuals
- Heat maps
- View factors sums

### Simulation features

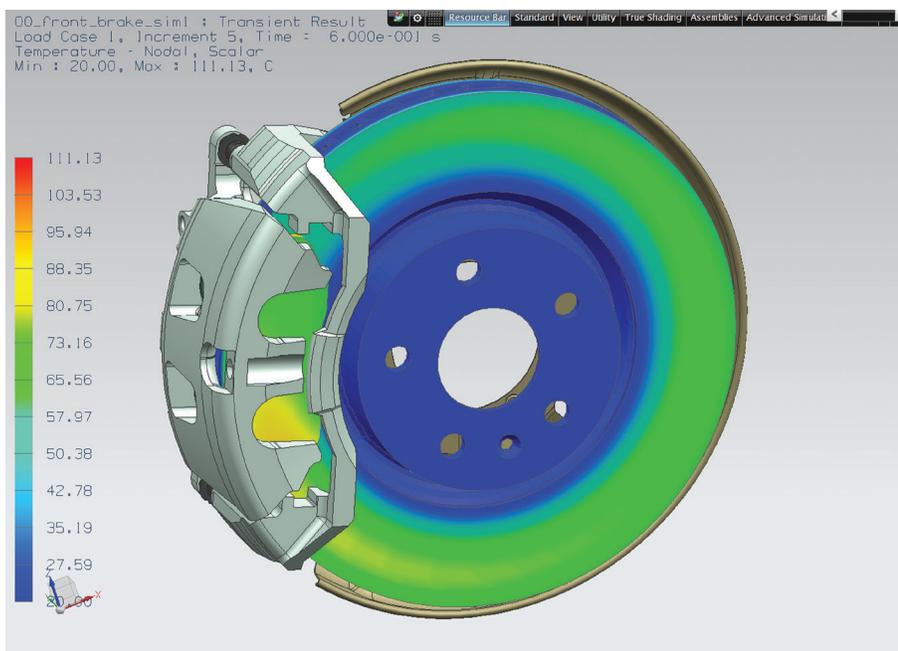
#### Thermal couplings for joining disjoint solid or surface meshes within assembly context

Thermal couplings provide a powerful and efficient capability for building assemblies by modeling heat flow between unconnected parts and components. Multiple what-if scenarios and positioning of parts within an assembly can be investigated by defining the thermal coupling parameters between unconnected parts only once. Heat transfer paths are automatically created between elements on opposing parts at runtime. These conductances are established based on surface proximity, and account for overlap and mismatch between disjoint and dissimilar meshes exchanging heat, allowing parts to be moved freely within the assembly prior to running the analysis. Thermal coupling types include conductive, radiative and interface couplings. Thermal couplings can also be defined as varying with temperature or time and space location.



#### Coupled thermo-fluid and thermoelastic simulations

The heat transfer modeling capabilities can be explicitly combined with the Simcenter 3D Flow or Simcenter 3D Advanced Flow computational fluid dynamics (CFD) solution (also available within the Simcenter 3D environment). These combinations allow a user to simulate fully-coupled thermo-fluid interactions problems, including integration of radiative heat transfer. When Simcenter 3D Flow and Simcenter 3D Thermal are purchased together, the thermo-fluid simulation capability is automatically activated within Simcenter 3D at no additional cost, offering both conduction and radiation modeling to be fully coupled with 3D fluid flow. Furthermore, Simcenter 3D Thermal temperature results can be mapped to a separate Nastran® FE model for thermoelastic analysis.



### Integrated thermal and heat transfer solution

Simcenter 3D Thermal is an add-on to the Simcenter Engineering Desktop application which provides capabilities such as geometry modeling, synchronous technology, allowing quick geometry modifications without regard to how it was built, as well as the distributed meshing workflows leveraging the assembly FEM capabilities. The Simcenter 3D integrated application allows both skilled engineers and thermal specialists to avoid any additional transfer of input files or geometry conversions and manipulations breaking the associative link between the geometry and FE tasks. The thermal model is synchronized with the design and assembly intent through data associativity. Complete associativity with the design geometry means that the thermal mesh is automatically updated when the design or assembly is modified.

Simcenter 3D provides Simcenter 3D Thermal users with a broad set of tools for creating thermal models and analysis-ready geometry. A user can automatically (or manually) create an idealized part where easy abstraction of unnecessary geometrical features can be achieved. Every geometrical

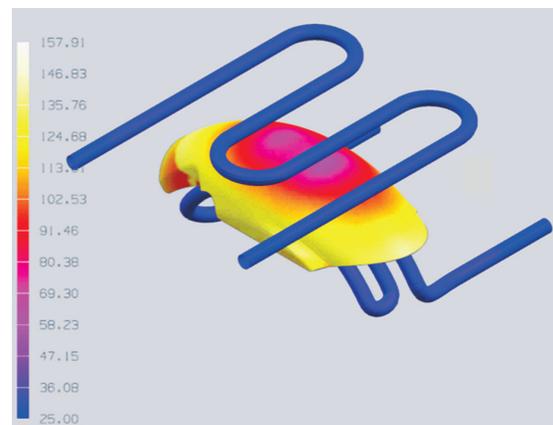
abstraction is associative to the part and assembly context. Automated free meshing tools enable quick parts modeling using precise sketches, surfaces and solid geometry. The user can refine the mesh in critical areas and selectively control mesh density, minimizing or optimizing model size for rapid and accurate solution.

By virtue of being integrated, Simcenter 3D Thermal provides the ability to model, catalog and share parts and material libraries among the design team, thereby minimizing tedious rework and potentially costly modeling errors.

#### Product availability

Simcenter 3D Thermal is an add-on module in the suite of Advanced Simulation applications available within the Simcenter 3D architecture. It requires a core seat of either Simcenter 3D Engineering Desktop or Simcenter 3D Structures as a prerequisite. When used in combination with Simcenter 3D Flow, Simcenter 3D Thermal provides a coupled multiphysics solution for complex fluid flow/thermal applications.

Simcenter 3D Thermal is available on most major hardware platforms and operating systems including Windows and Linux.



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