SIEMENS

Siemens PLM Software

LMS Samtech Samcef Thermal

Providing an accurate and robust platform for steady-state and transient-heat transfer analysis

Benefits

- Provides a comprehensive and powerful tool for steady-state and transient-heat analysis on complex structures
- Enables linear and nonlinear mechanical analysis to be performed on the same model as thermal analysis
- Allows decoupled and coupled thermomechanical analysis
- Offers advanced visualization tools for straightforward pre- and postprocessing of thermal analyses

Summary

LMS Samtech Samcef™ Thermal software from Siemens PLM Software can be used to perform heat transfer analysis due to conduction, convection and radiation on 2D axisymmetric and 3D structures. You can easily obtain the temperature and heat flow distribution in a model in which the material properties may depend on temperature and time. A variety of boundary conditions are available, from a simple imposed flux to complex interactions, such as mutual radiation and temperature-dependent contact conditions. Furthermore, LMS Samcef Thermal provides the structural analyst with the appropriate temperature distribution for a thermomechanical analysis. In order to enable users to exploit the power of integrated thermomechanical design, the access to LMS Samtech Samcef Solver Suite software is transparent.

Heat transfer analysis

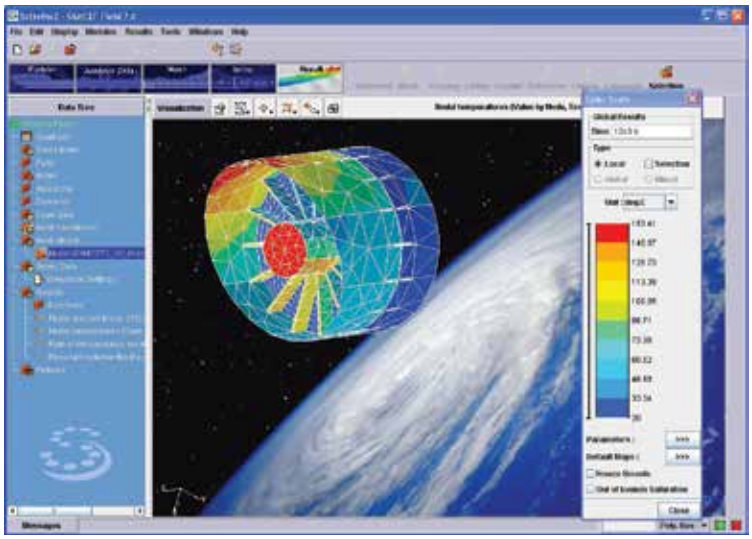
LMS Samcef Thermal provides you with a comprehensive and very powerful tool for steady-state and transient analyses. The user is free to switch from one type of analysis to another. For the conduction part of the analysis, an element library is available that includes the following components:

- 1D bar and specialized 0D elements
- 2D-axisymmetric volumes (with smeared out properties, if needed)
- 2D/3D membranes (triangles and quadrangles)
- 3D volumes (hexahedral, prism and tetrahedral elements)
- 3D multilayer shell and pipe elements

LMS Samtech Samcef Thermal

Features

- Enables seamless exchange between thermal and mechanical analysis
- User routines allow for the definition of custom user-defined boundary conditions and/or user-material models
- Ability to analyze the curing of composites
- Radiation view factors can be calculated for 2D axisymmetric and 3D geometries and between axisymmetric and 3D geometries
- Thermo-electromagnetic solution available (for example, lightning strike)
- Perform 1D- and 3D-coupled analysis for realistic simulation (for example, coupling with LMS Amesim)
- Can be coupled with LMS Samtech Boss Quattro to perform parametric studies, sensitivity analysis, statistical analysis, model updating, optimization, design of experiments and response surfaces



The conduction, which can either be isotropic or orthotropic, can depend on the temperature and time. The heat transfer capacity behavior of the material can be modeled as a function of temperature or by the use of an enthalpy formulation. This formulation is used to accurately integrate a phase change (presence of latent heat) process without major restrictions on the time step size.

Several models are available to analyze the curing of composites in which the curing reaction (endothermic, exothermic) has an impact on the temperature field. The state of cure can be transferred to a structural analysis for residual stress calculations. Besides the predefined curing laws, a user-defined material (user routines) can also be used.

In addition to the standard thermal analysis, a coupled thermo-electromagnetic analysis (Maxwell equations) is available in which the heating of the structure (due to an electric current) is calculated. If the structure is made of composites, the degradation of the composite material can be taken into account. Additionally, there are also different models available to represent molecular diffusion (water or chemical species).

Boundary conditions and imposed temperatures
The initial temperatures for either a nonlinear steady-state analysis or a transient analysis can be defined. Furthermore, one can impose nodal temperatures as a function of time.

Applied nodal flux
The simplest load will be a nodal flux, possibly as a function of time.

Surface and volume flux
It is possible to apply a surface flux to each face of an element. A standard surface flux exists, which can depend on time and/or temperature. It is also possible to define a user flux, which can either be a simple algebraic expression or a differential equation.

Free convection
To impose convection, a temperature-dependent convection coefficient and a fluid temperature can be defined or an enthalpy formulation can be used.

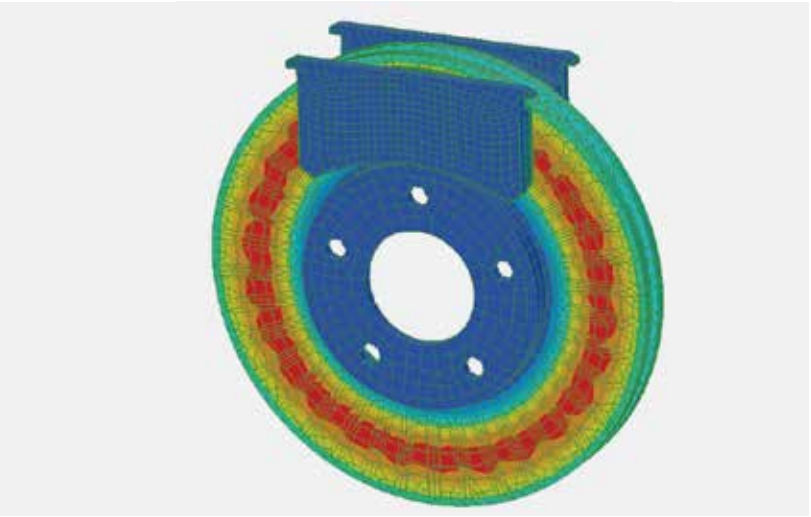
Forced convection in ducts
There is the functionality available to model a forced convection in plane, axisymmetric and 3D pipes. The input data consists of the correlation/convective coefficient, fluid density and the volume flow rate.

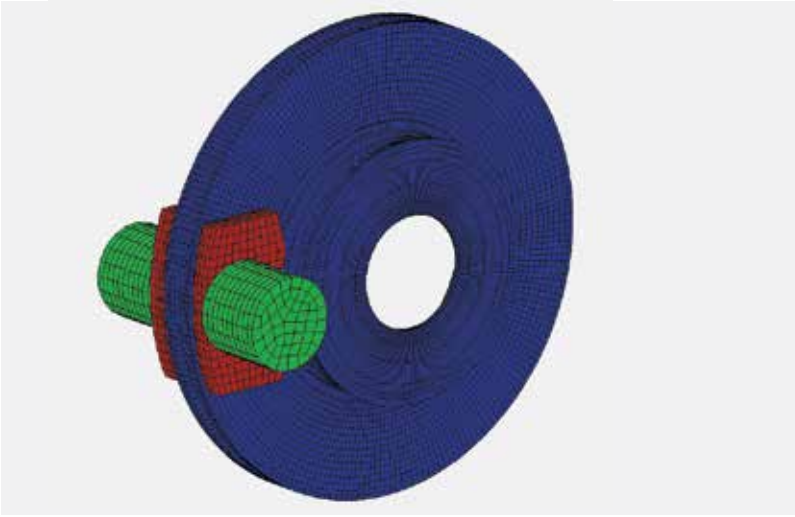
Mutual radiation and radiation
Mutual radiation involving diffuse radiation between semi-transparent surfaces can be analyzed with the assumption that no attenuation of the radiation heat (by the surrounding media) takes place. LMS Samcef Thermal possesses dedicated preprocessing commands to calculate the necessary view factors, taking into account the presence of:

- Reflective symmetry planes
- Screens blocking the view
- External heat sources
- Solar radiation plus shading

View factors cannot only be calculated for 2D axisymmetric and 3D geometries, but also between axisymmetric and 3D geometries. The emissivity, reflectivity and transparency can be a function of wave length (multiband approximation). The view factors can be calculated by either a ray-tracing algorithm or direct numerical integration (diffuse gray reflection). Besides mutual radiation, LMS Samcef Thermal enables you to apply classical radiation (with a black body) and flame radiation.

Volume radiation
In the case of semitransparent solids at high temperatures, the heat transfer balance contains a conductive and radiation component. This means that inside the structure the radiation exchange is solved in parallel with the heat conduction equation. A ray-tracing algorithm is applied that takes into account the wavelength-dependent emission, absorption and (non-isotropic) scattering of the material.





Contact
Specialized preprocessor commands exist to define contact conditions between different meshes. The contact zone can either be perfectly conductive or have a temperature-dependent interface conductance.

A special option is the application of cyclic symmetry conditions on a mesh.

Numerical control systems and functional (1D) models
With the help of numerical controllers and user-defined boundary conditions, it is possible to apply a nodal/surface/volume flux to one part of the structure, depending on, for example, the measured nodal temperature in another part of the structure. Additionally, a link exists with LMS Imagine.Lab Amesim™ software that allows for the integration of a 1D functional model (hydraulic, electrical, etc.) into the thermal model, exchanging temperature and a heat flux between the models.

Coupling LMS Samcef Thermal with other LMS Samcef products
Compatibility between LMS Samcef Thermal and other LMS Samcef modules allows a linear/nonlinear mechanical analysis to be performed on the same model as for thermal analysis. The file compatibility between LMS Samcef modules makes it possible to perform a structural calculation while taking into account an evolving temperature field provided by LMS Samcef Thermal.

The user will discover how easy it is to carry out a decoupled thermomechanical analysis: the temperature charts produced by using LMS Samcef Thermal can also be used for a mechanical analysis in LMS Samcef Structure linear modules or in LMS Samtech Samcef Mecano software.

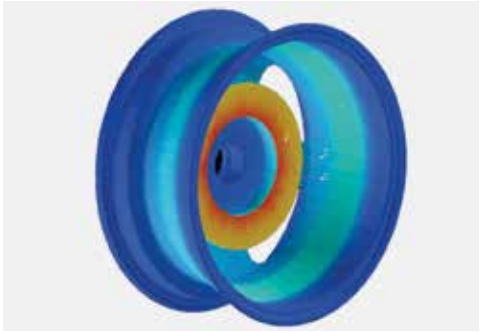
LMS Samcef Thermal can also be coupled with LMS Samtech™ Boss Quattro software, the application manager developed by Siemens PLM Software to perform parametric studies, sensitivity analysis, statistical analysis, model updating, optimization, design of experiments and response surfaces.

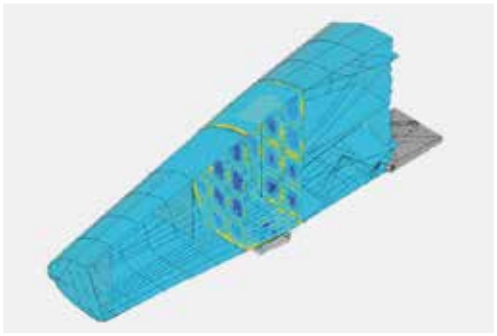
The following LMS Samcef modules are compatible with LMS Samcef Thermal:

- LMS Samcef Structure Linear: linear static, modal and buckling analyses and random response
- LMS Samcef Mecano is unique integrated software that solves nonlinear structures and mechanism problems. The software is intended to provide a more specific answer to following analyses: Mecano Structure, which is dedicated to the nonlinear analysis of structures, and Mecano Motion, which is dedicated to the static, kinematical and dynamic analyses of flexible mechanisms

Modeling environment
LMS Samcef Thermal is driven by an interactive graphical user interface (GUI) for the modeling, analysis and postprocessing of structures. Features include:

- Pull-down menus and popup boxes for data entry
- Computer-aided design (CAD) modeler that is incorporated for modeling and data preparation
- A wide selection of preprogrammed functions for the definition of time-varying properties
- Parameterized command language





Results are postprocessed graphically in the form of curves (time-wise evolution of a value) as iso-values (temperature at given instant) or as animations.

The thermal analysis of complex structures can entail the preprocessing of a huge amount of data. LMS Samcef Thermal provides advanced visualization tools, allowing very efficient and straightforward pre- and postprocessing of thermal analyses.

The results that can be postprocessed include:

- Temperature fields
- Heat flux distribution
- Time variation of nodal temperatures and element heat flux
- Externally applied flux

Also, different macro commands are available that allow for a thermal balance calculation; for example, one can measure the conductive flow passing through a predefined surface and/or to calculate properties of a group of elements, including:

- Average temperature
- Total applied flux, capacitive flux
- Repartitioning of applied flux (convection)
- Capacitive energy

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