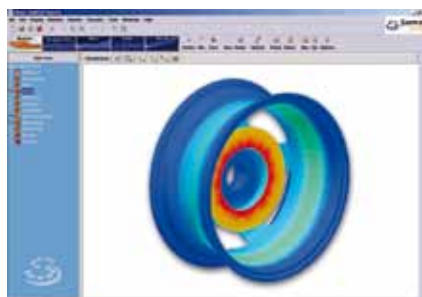
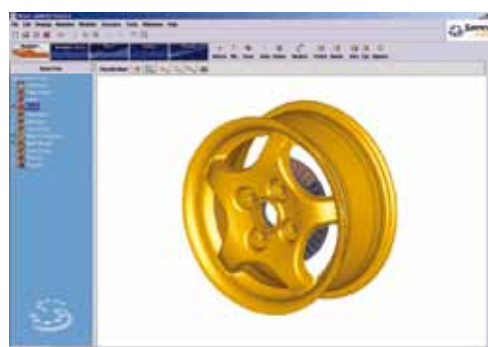
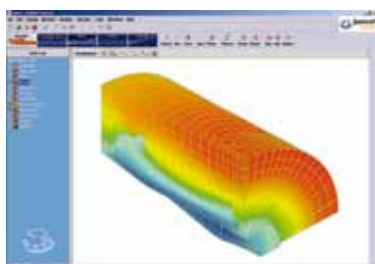
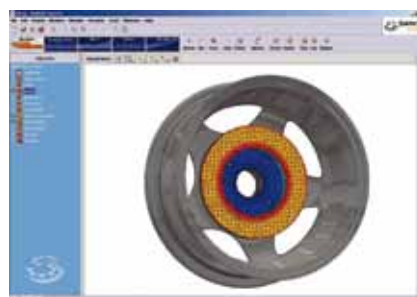


# SAMCEF Thermal



SAMCEF Thermal offers numerous capabilities for the analysis of **steady state and transient heat transfer** problems.

**T**aking into account heat transfer due to conduction, convection and radiation, SAMCEF Thermal users can analyze 2D axi-symmetric and 3D structures. One can easily obtain the temperature and heat flow distribution in a model, where the material properties may depend on temperature and time. A variety of boundary conditions is available, e.g. from a simple imposed flux to complex interactions such as mutual radiation and temperature dependent contact conditions. Furthermore, SAMCEF Thermal provides the structural analyst (SAMCEF Linear and SAMCEF Mecano) with the appropriate temperature distribution for a thermo-mechanical analysis. In order to exploit the power of integrated thermo-mechanical design, the access to SAMCEF solvers is transparent.

## CONDUCTION HEAT TRANSFER

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 the other. For the conduction part of the analysis, an element library is available which includes the following components:

- 1D bar and specialized 0D elements;
- 2D-axi-symmetric volumes (with smeared out properties, if needed);
- 2D/3D membranes (triangles and quadrangles);
- 3D volumes (hexahedral, prism and tetrahedral elements);
- 3D multi-layer shell and pipe elements.

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

The user can also study the influence of gas pressure (in a porous medium; using Darcy's equations), on the temperature distribution. Separate from the thermal analysis, there is also a model available to represent the moisture absorption in a porous material due to molecular diffusion.

## SOLUTION ALGORITHMS

For transient analysis, an implicit scheme (generalized mid-point scheme) is used to integrate the thermal equilibrium equations.

An automatic time step choice is available, which can use several criteria: optimal number of iterations, integration error and maximum allowable temperature variation  $\Delta T$ , while respecting imposed time instances.

At every time step of the transient analysis (or steady state analysis), a Newton method is applied, where one can chose between full or modified Newton.

## BOUNDARY CONDITIONS

### • Imposed temperatures

The initial temperatures for either a non-linear steady state analysis or a transient analysis can be defined. Furthermore one can impose nodal temperatures as a function of time.

### • Applied nodal flux

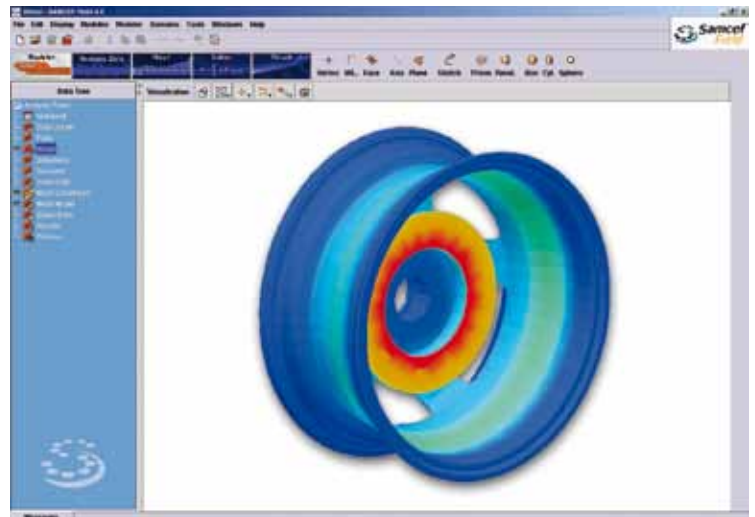
The simplest load will be a nodal flux possibly as a function of time.

### • 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 enthalpic formulation can be used.



### • Forced convection in ducts

Facilities are provided to model a forced convection in plane, axi-symmetric and 3D pipes. Convective coefficient, fluid density and the volume flow rate are the input data.

### • Mutual radiation and radiation

Mutual radiation involving diffuse radiation between opaque surfaces can be analyzed, under the assumption that no attenuation of the radiation heat (by the surrounding media) takes place. SAMCEF Thermal possesses dedicated pre-processing 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.

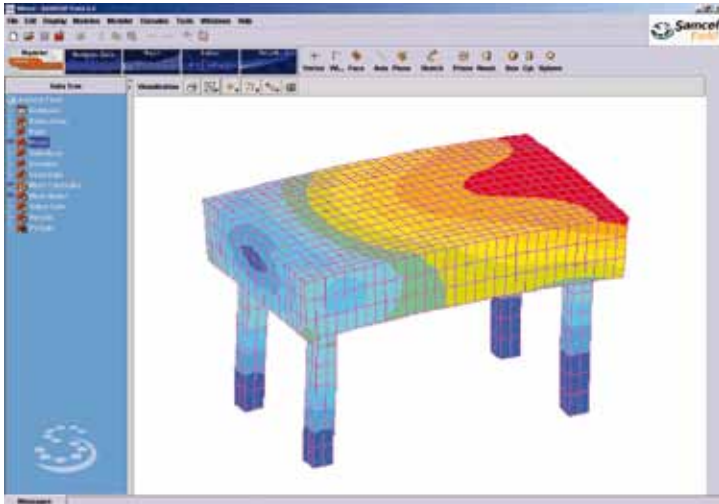
View factors cannot only be calculated for 2D axi-symmetric and 3D geometries, but also between axi-symmetric and 3D geometries. Also a dedicated pre-processor command is available to define mutual radiation between nodal capacity models. Besides mutual radiation, SAMCEF Thermal provides also the possibility to apply classical radiation (with a black body) and flame radiation.

### • Contact

Specialized pre-processor 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

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. The user can either program the numerical controllers or import them directly from MATLAB Simulink.



## COUPLING SAMCEF THERMAL WITH OTHER SAMCEF PRODUCTS FAMILY

Compatibility between SAMCEF Thermal and other SAMCEF modules allows a linear/non-linear mechanical analysis on the same model as for thermal analysis. The file compatibility between SAMCEF modules makes it possible to perform a structural calculation while taking into account an evolving temperature field provided by SAMCEF Thermal.

The user will discover how easy it is to carry out a decoupled thermo-mechanical analysis: the temperature charts produced by SAMCEF Thermal can be used for a mechanical analysis in SAMCEF Linear modules (ASEF, DYNAM, STABI) or in SAMCEF Mecano.

SAMCEF Thermal can also be coupled with BOSS quattro, the application manager developed by SAMTECH and allowing to perform parametric studies, sensitivity analysis, statistical analysis, model updating, optimization, design of experiments and response surfaces.

The following SAMCEF modules are compatible with SAMCEF Thermal:

- SAMCEF Field (FIELD = FInite Element Desktop): user environment providing all the tools necessary to design, analyze and simulate linear and non-linear thermo-mechanical systems, starting from the CAD geometry;
- SAMCEF Linear (Asef, Dynam, Stabi and Spectral): linear static, modal and buckling analyses, random response;
- SAMCEF Mecano: unique integrated software that solves non-linear structures and mechanisms problems. The software is declined to provide a more specific answer to following analyses:
  - MECANO Structure: dedicated to the non-linear analysis of structures;
  - MECANO Motion: dedicated to the static, kinematical and dynamic analyses of flexible mechanisms.

## MODELING ENVIRONMENT

SAMCEF Thermal is driven by an interactive graphical user interface for the modeling, the analysis and the post-processing of structures (SAMCEF Field).

- Pull-down menus and pop up boxes for data entry;
- CAD modeler is incorporated for modeling and data preparation;
- Wide selection of preprogrammed functions for the definition of time varying properties;
- Parameterized command language.

Results are post-processed 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 pre-processing of a huge amount of data. SAMCEF Thermal benefits of advanced visualization tools, allowing very efficient and straightforward pre- and post-processing of thermal analyses.

The results that can be post-processed includes:

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

Also different macro commands are available that allows to perform thermal balance calculations. One can measure the conductive flow passing through a pre-defined surface and/or to calculate properties of a group of elements:

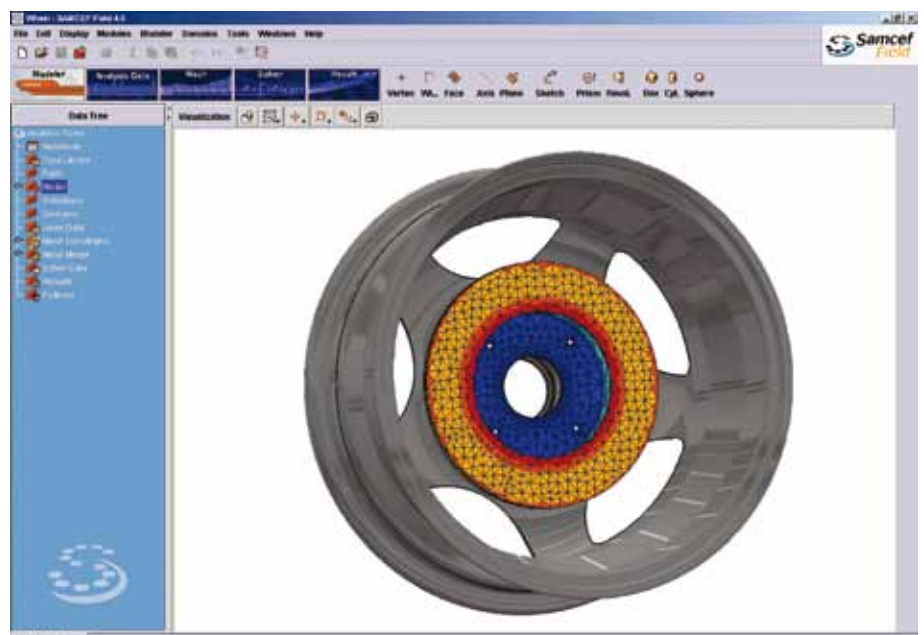
- Average temperature;
- Total applied flux, capacitive flux...;
- Repartitioning of applied flux (convection...);
- Capacitive energy.

## DOCUMENTATION

For direct access to information, the Users Guide and Help manual are available via your favorite navigator (HTML).

## PLATFORMS

SAMCEF Thermal is available on most Unix and Windows platforms.



## About SAMTECH

SAMTECH is a European specialist in the development and worldwide marketing of Computer Aided Engineering software, commonly called "simulation" or "Virtual Prototyping" software. It is well established that as well as increasing the quality of the design, such software not only enables drastic reductions in product development cycle and consequently the associated costs, but also dramatically reduces the need for expensive physical testing.

**"General-purpose software tools"**: this SAMTECH offer includes the general linear and implicit non-linear Finite Element Analysis package SAMCEF with the CAD/CAE modeling environment SAMCEF Field, the general explicit and fast dynamics code EUROPLEXUS; the task management and optimization platform BOSS quattro; TEA Mecano and TEA Thermal CAA V5 Based as non-linear thermo-mechanical solution embedded in CATIA V5 and SAMCEF Gateway CAA V5 Based, the SAMCEF integrated interface within CATIA V5.

SAMTECH most recent product, CAESAM, is a high level CAE centric Application Framework allowing the customization and the management of the whole engineering process, involving any commercial software and in-house skill tools. This environment based on Knowledge Based Engineering concept encapsulates customer skills and knowledge into Analysis Processes and Analysis Methods and ensures reusability of models in order to reduce Time-to-Market.

**"Professional products"**: this SAMTECH offer is based on its general-purpose software tools and is dedicated to specific domains of application such as rotor dynamics (SAMCEF for Rotors), modeling of pipes for automotive industry (TEA Pipe), modeling of high voltage substations, electrical lines (SAMCEF for Power Lines and Substations), prediction of dynamic loads on wind turbine drive trains (SAMCEF for Wind Turbines)...

**"Third party and customized solutions"** like the SAFE tool (fatigue analysis of aeronautic structures) and the Application COMPOSITES (analysis of aeronautical structures made of composite materials) from AIRBUS, where SAMTECH provides its clients with services such as development, reengineering, packaging and deployment of proprietary professional solutions on the customer site.

**"Customized multi-physics solutions"**, based on OOFELIE. OPEN ENGINEERING, the SAMTECH subsidiary, which allows SAMTECH to be present in the multi-physics design markets and to provide services for the development of original highly coupled analysis solutions covering specific needs, commercializes OOFELIE.

Visit [www.samtech.com](http://www.samtech.com) for further details on SAMTECH Product/Service offer!

## Some references

### Space

ASTRIUM ST, SAFRAN GROUP, ESA / ESTEC, CNES, ALENIA, ISRO...

### Aeronautics

AIRBUS, SPIRIT AEROSYSTEM, AVIC-GROUP, SABCA, SONACA...

### Aero engines

TECHSPACE AERO, SAFRAN GROUP, GTRE, MTU...

### Automotive

DAIMLER, PORSCHE, PSA, TOYOTA, DELPHI AUTOMOTIVE, MITSUBISHI, TATA DAEWOO...

### Energy

AREVA, EDF, GENERAL ELECTRICS, SIEMENS, REPOWER...

### Defense

MBDA, GIAT INDUSTRIES, FORGES DE ZEEBRUGGE...

### Miscellaneous

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