I-DEAS® TMG Thermal Analysis

for fast and accurate solutions to complex thermal problems

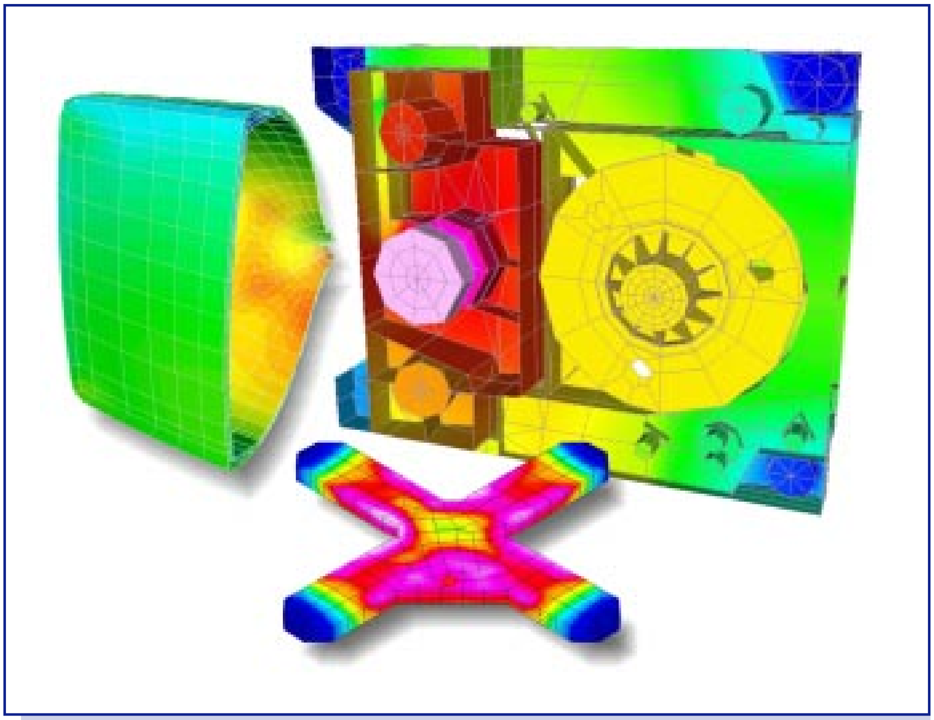
Best-of-Class Thermal Simulation

I-DEAS® TMG Thermal Analysis software is a comprehensive modeling and simulation package. It provides fast and accurate solutions to complex thermal problems. Using advanced numerical techniques, I-DEAS TMG makes it easy to model nonlinear and transient heat transfer processes including conduction, radiation, free and forced convection, fluid flow, and phase change. Leading edge solver technology provides solid reliability and superior solution speed for even the most challenging problems. With I-DEAS TMG Thermal Analysis, accurate thermal analysis can be performed quickly and effectively, delivering the engineering insight and turnaround speed needed to ensure success within today's rapid development cycles.

Integrated Thermal Analysis

I-DEAS TMG is completely integrated within I-DEAS, allowing you to carry out sophisticated thermal analysis as part of a collaborative engineering process. The software enables 3D part modeling to be used as the foundation for thermal analysis by allowing you to efficiently create and fully associate FE models with abstracted analysis geometry. All of the thermal design attributes and operating conditions can be applied as history-supported entities on 3D model geometry.

The software incorporates sophisticated technologies for the efficient solution of element-based thermal models. A rigorous control volume scheme computes accurate conductive terms for even highly skewed meshes. Radiative heat transfer is computed using an innovative combination of radiosity and ray-tracing techniques; hemicube technology and sparse matrix solvers enable the code to easily solve very large radiative models. For analysis of assemblies, I-DEAS TMG provides powerful tools to connect disjoint meshes of parts and components. The package offers outstanding model solution technology: a state-of-the-art BiConjugate Gradient solver delivers exceptional speed, reliability, and precision.



I-DEAS TMG is ideal for modeling individual components to large assemblies. I-DEAS TMG can effectively simulate complex nonlinear and transient thermal behavior including conduction, convection, radiation, phase change and fluid flow.

The I-DEAS TMG user interface is icon-driven and forms-based to minimize learning time and enhance productivity. Units can be selected on individual forms for each entry field. Context-sensitive on-line help is always only a click away. The solution process is highly automated and fully integrated, which means that no additional input files are required and all analysis is carried out in a single pass. Thermal results are directly available for loading structural models and can be mapped onto a different mesh. These features, combined with a variety of interfaces and customization options, make I-DEAS TMG Thermal Analysis an ideal solution for any engineering environment.

Comprehensive Thermal Modeling Tools

Thermal problems in mechanical and electronic systems are often difficult to detect and resolve because of the complex effects of convection or radiation. I-DEAS TMG provides a broad range of tools to model these effects, and leading-edge simulation technology to get fast and accurate results.

Conduction

I-DEAS TMG Thermal Analysis uses a conservative element-based control volume formulation to compute accurate conductive and capacitive terms for arbitrary, unstructured meshes. The proprietary scheme is based on an element temperature function constrained at calculation points on the boundaries and at the geometric centroid. The resulting solution matrix is extremely accurate, stable, and fully compatible with finite difference solvers such as SINDA. The approach also supports the direct insertion of user-calculated conductance terms and the manipulation of the solution matrix in user-supplied code.

The software supports a wide variety of element types, including solids, shells, and beams, as well as axisymmetric elements. A unique multi-layer shell formulation is provided, for efficient modeling of laminates, honeycomb panels, and high performance insulation. Orthotropic and temperature dependent thermal conductivity is supported for all element types, as is phase change.

Thermal Couplings

Thermal couplings provide a powerful and efficient capability for building assemblies by modeling heat flow between unconnected parts and components. Conductances are created between elements coated on the corresponding surfaces or edges. The couplings are established based on element proximity and are distributed to account for overlap and mismatch between disjoint or dissimilar meshes. Coupling types include conductive, radiative, convective, and interface.

Boundary Conditions

A wide range of load, restraints, and boundary conditions can be applied to an I-DEAS TMG thermal model, using either the standard I-DEAS capabilities or specialized I-DEAS TMG tools. Boundary conditions can be defined on nodes, elements, surfaces, or volumes; data applied to solid model geometry is fully associative, and automatically updated if the part and its associated mesh is changed. The capabilities include:

•Fixed or initial temperatures
•Heat loads and fluxes (surface or body)
•Radiative and convective boundary conditions
•Transient loads and restraints
•Data surfaces for spatially-varying boundary conditions
•Time-averaged heat loads
•Thermostats with hysteresis
•Import of external CFD data

Coupled thermal/fluid

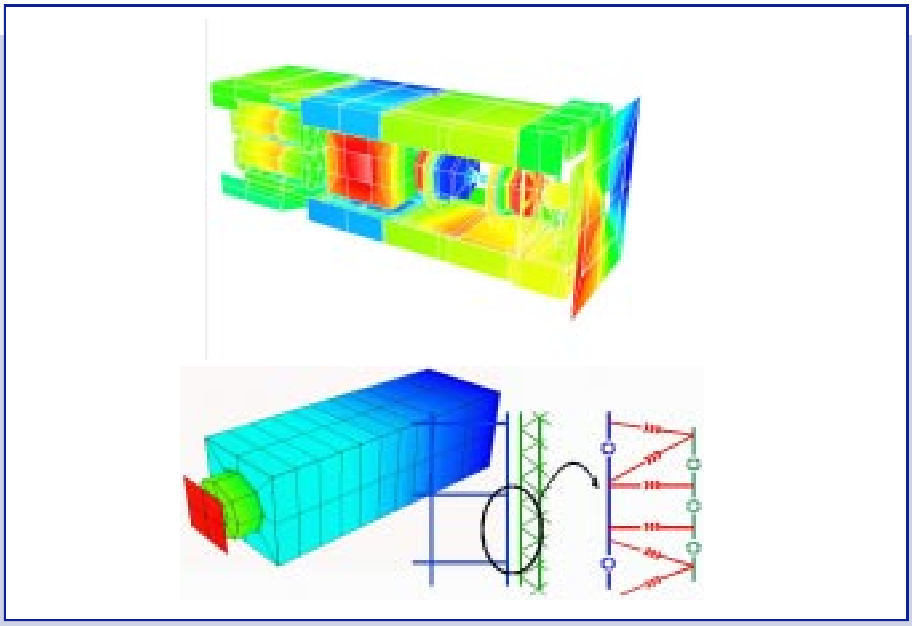
You can accurately model the effects of forced and natural convection within conjugate heat transfer problems. I-DEAS TMG duct flow enables you to quickly and easily model one-dimensional networks, while the I-DEAS Electronic System Cooling™ package provides full CFD capabilities for simulating complex 3D flow systems. Thermal Coupling tools enable you to couple flow models with an I-DEAS TMG model, even if the meshes are dissimilar, and to compute convective heat transfer coefficients based on the coupled solution.

Joule Heating

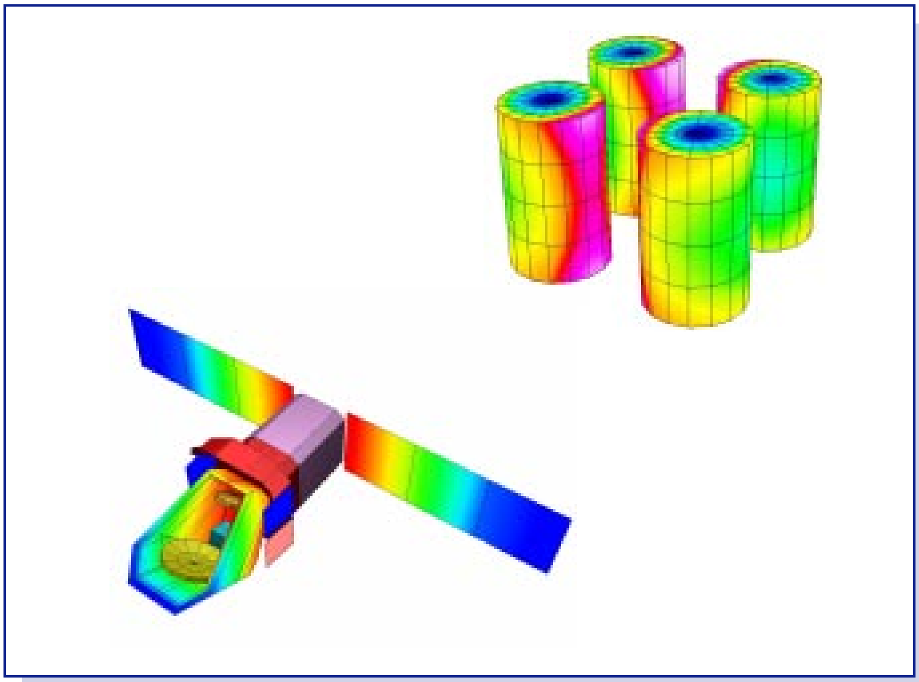
I-DEAS TMG can simulate the effects of Joule Heating. Current flow density is computed based on voltage boundary conditions and electrical resistivity. The electrical properties can vary with temperature, providing full coupling with the thermal model.

Model Reduction

Model simplification tools are available for simplifying or conditioning a thermal model matrix prior to solution. They include element deactivation, conductance thinning, element merging, and model substructuring.



I-DEAS TMG powerful thermal coupling technology makes it easy to create complex thermal assemblies containing many individually meshed parts. Element meshes do not need to match, saving considerable meshing time and simplifying your model.



I-DEAS TMG radiation can model a wide range of radiative effects, including multiple enclosures, specular and transmissive surfaces, solar or high temperature sources, orbital heating, articulating systems, and temperature-dependent emissivity.

Model Management

Comprehensive tools are provided for model management, including:

- multiple solution cases
- activation/deactivation of boundary conditions
- data reuse
- solution restarts
- solve directories
- batch solves

Advanced Radiation Simulation

I-DEAS TMG Radiation provides comprehensive simulation of radiative heat transfer. The system offers capabilities for modeling a wide range of radiative effects, including multiple enclosures, specular and transmissive surfaces, solar or high temperature sources, orbital heating, articulating systems, and temperature-dependent emissivity. The solution of the radiative exchange problem is based on a radiosity formulation, using a combination of hemicube and ray-tracing techniques to compute the direct view factors.

Surface geometry for radiation models is defined using shell elements created directly on part surfaces. For accurate modeling of focusing effects, curved surface elements can be used. Visualization and control of the element orientation is provided, including consistency checking, reverse side modeling, and element deactivation. Axisymmetric elements are supported for radiation modeling.

Enclosure modeling is either automatic or under user control via view factor requests. A default enclosure model is provided for an ambient environment, with control over the element density. View factor sums are automatically normalized using an iterative procedure.

View factors can be computed using a hemicube algorithm, in which the radiating elements are rendered onto the planes of a half cube. By exploiting the graphics hardware to do this, view factor calculation time is dramatically reduced, particularly for large models. Comprehensive error checking and correction schemes ensure that aliasing effects and other errors are minimized. Form factors can also be calculated using standard analytical techniques: a contour integral technique for unobstructed views, and a Nusselt Sphere method for shadowed elements, with adaptive subdivision used to maximize accuracy.

The effects of specular reflections and transmissions in a radiative exchange problem are computed using an advanced ray tracing procedure, which adjusts the view factor matrix in a second pass. Rays are launched between elements based on the view factors, and are traced through the enclosure until they are extinguished. User control over ray density is provided. Angle-dependent properties are also supported.

I-DEAS TMG uses a radiosity approach (Oppenheim's Method) to construct the radiative exchange matrix; an advanced sparse matrix solver is used to solve the equations, providing very fast performance for even the largest models. A matrix inversion solution based on Gebhardt's Method is also available for calculation of direct radiative terms.

Radiative Heating

Radiative heating by diffuse or collimated sources can be modeled. A bi-spectral capability allows I-DEAS TMG to easily simulate high-temperature lamps or other radiative heat sources.

Orbital Heating

I-DEAS TMG incorporates a complete, integrated capability for analysis of environmental heating of spacecraft, including direct solar, albedo, and planetary flux. The package includes a sophisticated system for modeling complex mission profiles for spacecraft thermal analysis:

- •Comprehensive database of planet/sun characteristics
- •Variety of orbit definition methods, including beta angle, classical, sun synchronous, and sun/planet vectors
- •Automatic detection and modeling of eclipse
- •Vector-based spacecraft attitude modeling
- •Orbital maneuvers
- •Partial and sequential orbits
- •Spinning spacecraft
- •Arbitrarily spaced orbit calculation points
- •Orbital heat loads automatically loaded into the solution matrix

A state-of-the-art orbit visualization system enables you to quickly validate the orbit definition via an animated display of the spacecraft model as it follows the orbital trajectory.

Articulation of assemblies such as spacecraft solar arrays or robotic systems can be easily and efficiently simulated. Graphical tools are provided for characterizing the rotation or translation of subassemblies, and for displaying temperature results on the displaced geometry.

Diurnal Heating

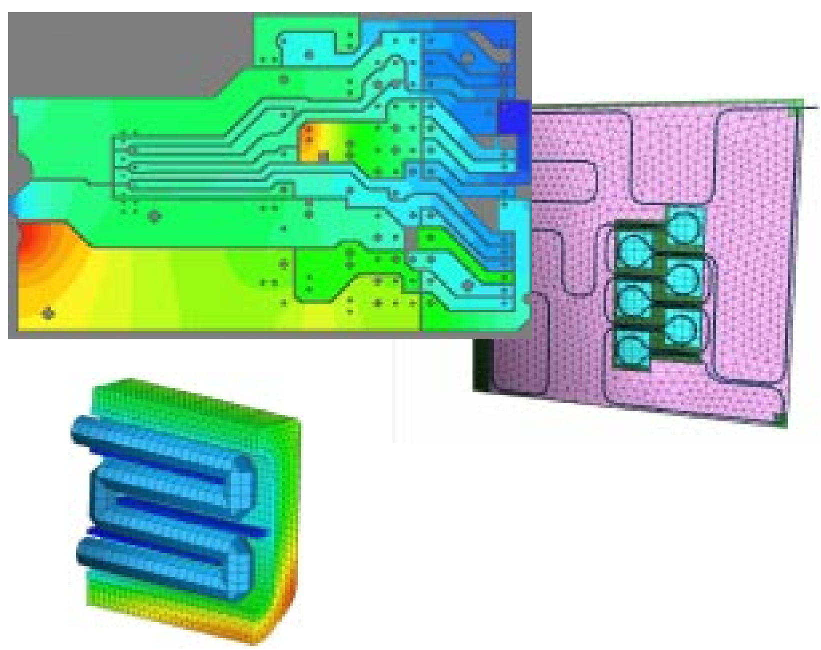
Diurnal solar heating can be calculated, given a specified latitude and orientation. Various options are provided for modeling atmospheric and ground effects.

Duct Flow

I-DEAS TMG duct flow provides integrated simulation of one-dimension fluid flow and convective heat transfer. The capability is based on the control volume approach to formulate separate pressure-flow and advection models from a duct network characterization of the fluid system. The fluid model is coupled to the thermal model by convective conductances and is solved in parallel with it.

Duct flow models are constructed by assembling networks of one-dimensional flow elements. I-DEAS TMG Thermal Analysis automatically computes flow resistances from duct geometry and updates the values as the solution converges. Transitions between laminar and turbulent duct flow regimes are automatically detected and modeled. Variable fan curves or pump characteristics can be specified as boundary conditions, as well as fixed pressures or flow conditions. Obstructions are modeled by specifying duct roughness values or by user-defined flow resistances. Buoyancy effects in the fluid network are treated explicitly. For advanced applications such as turbine blade cooling, I-DEAS TMG Thermal Analysis models compressibility effects and rotating systems.

Forced and free convection can be simulated accurately and efficiently using fluid models. Convecting elements in the thermal model are automatically coupled to the appropriate fluid elements, even if the meshes are dissimilar I-DEAS TMG Thermal Analysis computes a convective heat transfer coefficient based on a Nusselt number formulation, and updates this value as both the flow and thermal solutions iterate, distinguishing between laminar and turbulent flow regimes. Constant or variable convection coefficients or multipliers can also be defined.



I-DEAS TMG provides advanced coupled-physics simulation. Models can combine duct fluid flow, electric (Joule) heating, phase change, transient boundary conditions, thermostats as well as conduction, convection and radiation.

State-of-the-Art Solver Technology

I-DEAS TMG delivers advanced solver technology designed to handle your largest and most challenging problems. At the core of the solution algorithms is a state-of-the-art BiConjugate Gradient solver which provides exceptional solution speed with high reliability.

Steady-state solves are carried out iteratively, using a Newton-Raphson approach for the nonlinear terms. Transient simulation algorithms include explicit, implicit, and exponential forward methods, with full user control over time step and implicit parameters.

To accelerate convergence, the solution algorithms are designed to minimize updates of the radiative conductances, based on the temperature change. The software will also automatically detect poor solution convergence, and adjust the solver parameters dynamically.

Solution control is extensive and includes: relaxation factor; iteration limit; convergence criteria based on temperature or energy residual; constant or variable integration time step; and results output interval. Solution traces and other diagnostics are provided.

Sophisticated Post-Processing

The following simulation results are available for visualization and post-processing, and can be optionally written to a report file:

- Temperatures
- Heat fluxes
- Temperature gradients
- View factor sums
- Solar and planetary view factors
- Duct Flow results
- Convective coefficients
- Error residuals
- Conductance network

Temperature Mapping

Temperature Mapping allows you to quickly and accurately map thermal model results onto another finite element model with a different mesh. This enables coupled thermal and structural analysis to be performed concurrently without using the same element mesh.

The mapping system allows you to specify zones of correspondence between the two models, and to compute transverse temperature gradients to be applied to shell elements in the structural model.

Diagnostics and Validation

I-DEAS TMG Thermal Analysis offers a powerful methodology for thermal model validation and test data correlation through the manipulation and optimization of physical parameters such as material properties, conductances, or loading conditions. The software includes a comprehensive set of tools for performing sensitivity analysis, uncertainty analysis, model diagnosis, and parameter studies, which enable users to quickly characterize the dominant heat paths and critical parameters in a thermal model. A capability is provided to compute thermal model parameters which optimize correlation with test results. The software is based on an innovative approach in which the measured temperatures are mapped onto the original thermal model as boundary conditions and the resulting heat flows into each element are computed. These energy residuals can then be used to identify areas of heat flow discrepancy and the physical parameters likely to be in error. Solution routines are provided to iteratively update selected model parameters to minimize energy residuals or RMS temperature differences.

Data Exchange

Interfaces are provided to several other thermal analysis programs. I-DEAS TMG can export thermal models to create SINDA, ESATAN, TRASYS, or NEVADA input files. Results from SINDA and ESATAN can be converted back to I-DEAS TMG for post-processing. Existing NEVADA or SINDA models can also be imported to I-DEAS TMG.

Open Architecture

I-DEAS TMG offers a wide variety of customization capabilities and execution options via its open architecture.

Direct access to the solution process is provided via an open subroutine, enabling you to model complex phenomena, customize the numerical solution, or integrate third-party code. Solver access is provided via an open subroutine, which is automatically compiled and linked at run time. The subroutine provides access to all model parameters during the solution process, for virtually unlimited customization. Diverse tools are provided for extracting data from the model, including group names, conductances, material and physical properties, element geometry, and boundary conditions. Data computed in user subroutines can be easily recovered in I-DEAS format for post-processing.

The data for an I-DEAS TMG solve is captured to an ASCII input file which is free format, well documented, and user editable; batch solves can be run using this file. The I-DEAS TMG input file also offers a variety of additional ustomization options, including variables, equations, and SINDA-type entry of conductance-capacitance terms. I-DEAS TMG's main solution files are also documented and in ASCII format, to facilitate model validation, data management, and customization.

Quality Assurance

I-DEAS TMG Thermal Analysis is rigorously tested using an extensive suite of verification test problems. A verification guide is available upon request.

Prerequisites

Core Simulation

For More information

For more information, contact your local SDRC representative or call 1-800-848-7372.