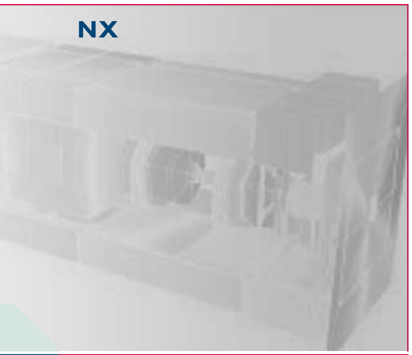


NX TMG Thermal Analysis

Fast and accurate solutions to complex thermal problems

fact sheet

www.ugs.com

Summary

NX TMG Thermal Analysis (TMG) within I-deas® NX Series provides rapid and accurate thermal modeling and simulation. Augmenting the capabilities of NX MasterFEM, 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 TMG, 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.

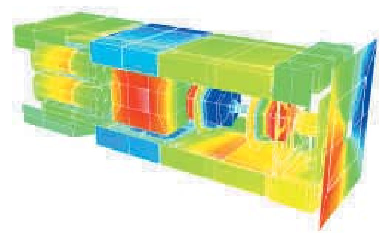
Features

- Use advanced numerical techniques to model nonlinear and transient heat transfer processes
- Use 3D part modeling as the foundation for thermal analysis, creating and associating FE models with abstracted geometry
- Use sophisticated technologies for the efficient solution of element-based thermal models
- Perform analysis of assemblies with tools that connect disjointed meshes
- Employ thermal results that are directly available for loading structural models and can be mapped onto a different mesh

Benefits

- Perform accurate thermal analysis quickly and efficiently
- Perform integrated thermal analysis as part of a collaborative engineering process
- Minimize learning time and enhance productivity via icon-driven, forms-based interface
- Use a highly automated and integrated solution process that requires no additional input files and carries out analysis in a single pass

NX TMG Thermal Analysis



NX TMG Thermal Analysis (TMG) is completely integrated within I-deas NX Series, enabling you to carry out sophisticated thermal analysis as part of a collaborative engineering process. TMG enables 3D part modeling to be used as the foundation for thermal analysis by enabling 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.

TMG Thermal Analysis 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, TMG provides powerful tools to connect disjoint meshes of parts and components. TMG offers outstanding model solution technology: a state-of-the-art biconjugate gradient solver delivers exceptional speed, reliability and precision.

The TMG user interface is icon-driven and forms-based, minimizing learning time and enhancing productivity. Units can be selected on individual forms for each entry field. Context-sensitive online 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 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. TMG provides a broad range of tools to model these effects and leading edge simulation technology to get fast and accurate results.

NX

Conduction

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.

TMG 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 capability for building assemblies by modeling heat flow between contacting parts and components. Conductances are created between elements on the interacting surfaces or edges based on element proximity. The mesh on the corresponding surfaces can be completely disjoint or dissimilar. Sliding contact in articulating assemblies can also be modeled. Thermal coupling types include conductive, radiative, convective and interface.

Boundary conditions

A wide range of load, restraint and boundary conditions can be applied to a TMG thermal model using either the standard capabilities within I-deas NX Series or specialized 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
- Thermoelectric coolers
- Import of external CFD data

Coupled thermal/fluid

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

Joule heating

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. For large radiation models, an automated patching scheme based on element clusters provides effective condensation of the solution matrix with minimal impact on fidelity.

Model management

Comprehensive tools are provided for model management, including:

- Multiple solution cases
- Activation/deactivation of boundary conditions
- Data re-use
- Solution re-starts
- Solve directories
- Batch solves

Advanced radiation simulation

TMG radiation tools provide 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.

TMG also offers a comprehensive capability for constructing primitives-based radiation models. You can quickly generate and manipulate primitive shape objects that are element-based for TMG solutions but are exported as complete surface primitives to external radiation codes such as TSS and Esarad. 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, an OpenGL rendering-based scheme which delivers unmatched performance for large models.

Form factors can also be calculated using standard analytical techniques: a contour integral technique for unobstructed views and a Nusselt Sphere method with adaptive subdivision for shadowed elements. The effects of specular reflections and transmissions in a radiative exchange problem are computed using an advanced ray-tracing procedure that adjusts the view factor matrix in a second pass. Rays are launched between elements based on the view factors, and they are traced through the enclosure until they are extinguished. User control over ray density is provided. Angle-dependent properties and refraction are also supported. 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 enables TMG to easily simulate high-temperature lamps or other radiative heat sources.

Orbital heating

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
- Tracking-based articulation
- Partial and sequential orbits
- Spinning spacecraft
- Arbitrarily spaced orbit calculation points
- Explicit planet model
- 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

TMG duct flow provides integrated simulation of one-dimensional 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.

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, TMG 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. TMG computes a convective, heat transfer coefficient based on a Nusselt number formulation, updating this value as both the flow and thermal solutions iterate and distinguishing between laminar and turbulent flow regimes. Constant or variable convection coefficients or multipliers can also be defined.

State-of-the-art solver technology

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 that 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. TMG 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
- Heat flows between element groups

Temperature mapping

Temperature mapping enables you to quickly and accurately map thermal model results onto another finite element model with a different mesh. Then coupled thermal and structural analysis can be performed concurrently without using the same element mesh. The mapping system enables 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

TMG offers a powerful methodology for thermal model validation through the manipulation and optimization of physical parameters such as material properties, conductances or loading conditions. TMG includes a comprehensive set of tools for performing sensitivity analysis, uncertainty analysis, model diagnosis and parameter studies, which enable you to quickly characterize the dominant heat paths and critical parameters in a thermal model.

System requirements

NX TMG Thermal Analysis shares the I-deas NX Series system requirements.

Recommended system configuration

For information on particular operating systems or graphics cards, please visit http://support.plms-ugs.com/online_library/certification/

Data exchange

Interfaces are provided to several other thermal analysis programs. TMG can export thermal models to:

- Sinda
- Esatan
- TSS
- Esarad
- Thermica
- Trasys

Results from Sinda and Esatan can be converted back to TMG for post-processing. Existing radiation models in TSS, Esarad and Thermica format can be imported into TMG.

Open architecture

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 that 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 NX Series format for post-processing.

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

Quality assurance

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

Contact
UGS

Americas **800 498 5351**
Europe **44 1276 705170**
Asia-Pacific **852 2230 3333**

www.ugs.com

UGS The PLM Company