

# Overview of TMG Features

TMG Thermal Analysis is a comprehensive heat transfer simulation module. You can use TMG to model heat transfer by conduction, convection, radiation, fluid flow, and phase change. Thermal models are solved using advanced finite control volume technology, under steady-state or transient loading conditions.

Following is a brief summary of TMG's features and capabilities.

## Conduction

Heat transfer by conduction is accurately modeled for arbitrary element meshes. Elements may have the following characteristics:

- temperature varying thermal conductivity
- temperature varying specific heat and density
- phase change
- orthotropic thermal conductivity
- axisymmetry
- radial heat flow

## Thermal Couplings

Thermal couplings can be created between dissimilar element meshes. This is useful for modeling thermal interfaces, as well as applying convective or radiative boundary conditions to a model. Thermal Couplings also provide a convenient method for assembling a thermal model from unconnected component models.

## Fluid Flow

You can use TMG to construct accurate models of one dimensional flow systems. Pressure drops and mass flow through a network is simulated. TMG determines the hydraulic flow resistance through each duct element based on its length and flow section. The flow model is connected to the thermal model via convective thermal couplings, and the two models are solved in parallel, accounting for the advective heat transfer by the fluid. Buoyancy effects are modeled, enabling simulation of natural convection in the flow channels.

## Convection

Analysis of forced and free convection is provided. Standard correlations are provided for convection from regular surfaces to a static or moving fluid. The correlations use the fluid properties and flow data of the attached fluid element to evaluate the correlation. The convective heat transfer coefficients are dynamically updated during the solution convergence. You can also modify or supplant TMG's built-in correlations.

## Radiation

TMG provides full simulation of radiative heat transfer in enclosures. View factor techniques are used to model the connections between surface elements due to diffuse emission and

reflection of thermal radiation. Shadowed view factors are computed using element subdivision. Specular reflections are handled using ray-tracing. Multiple enclosures can be modeled, and are automatically detected and handled by TMG. Radiation models may be axisymmetric.

## **Radiative Heating**

Heating of a model by radiative sources can be simulated. The radiative heating may be direct solar flux, direct infrared flux, diffuse flux from an arbitrary shaped object, or environmental heating of an orbiting spacecraft. View factor techniques are used to model the diffuse reflection of incident radiation, while ray-tracing is deployed for specular processes.

## **Additional Modeling**

You can augment a TMG thermal model by adding non-geometric elements and conductances.

## **Boundary Conditions**

The thermal model boundary conditions comprise temperatures, heat loads, heat fluxes (surface or body), and initial temperatures. These may be specified as constant or time varying. Automated modeling of thermostats with hysteresis is also provided.

## **Model Simplification**

A number of tools are available in TMG for simplifying or pre-conditioning a thermal model to reduce its solution time. These include element deactivation, merging, and elimination. Models can be sub-structured to reduce the size of the solution matrix.

## **Thermal Model Solution**

A TMG thermal model can be solved under steady-state or transient conditions. A robust and efficient iterative solver is used for steady-state models, with user control over damping, acceleration, and convergence criteria. The transient solver provides full control over the integration scheme, time step selection, and iterative processes.

## **Results Data**

A wide range of thermal simulation results are available for post-processing and visualization. Comprehensive reports of thermal data can also be generated by TMG. Data from a previous run can be selectively reloaded for a subsequent analysis (a "restart" capability). The thermal model geometry can also be exported to TRASYS or SINDA.

## **Temperature Mapping**

You can map the temperature results from a TMG thermal model onto a second model with a different mesh.

## **User Subroutines**

You can develop a subroutine which is automatically linked with the TMG solver. The subroutine has access to all thermal model parameters, and can be used to dynamically recompute values during the solution process.

## **Effective Program Limits**

Maximum number of nodes: 10,000,000

Maximum number of elements: 10,000,000

View factor limitation: No limit on UNIX platforms. On the Windows platform, the file VUFF (where view factors are stored) cannot exceed 2 Gb in size; this limit is generally reached with view factors in the order of 35 million.

Largest permissible material or property ID number: 99999

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