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Femap Advanced Thermal Solver

Benefits

- Allows for investigation of multiple "what-if" scenarios involving complex assemblies
- Facilitates building of assemblies by modeling heat flow between unconnected parts and components
- Enables the user to simulate strong and fully-coupled thermo-fluid interactions, including proper treatment of radiative heat transfer
- Supports mapping results to a Nastran® FE model for thermo-elastic analysis

Summary

Femap™ software's Advanced Thermal module, part of the Simcenter solutions, is an add-on to Femap Thermal and includes a complete set of solver capabilities to treat complex heat transfer problems. The additional thermal and heat transfer capabilities offer high fidelity numerical predictions and address additional thermal analysis requirements in many industries. The Femap Advanced Thermal solver can also be seamlessly coupled with Femap Flow, the Femap CFD solution, for fully coupled advanced thermo-fluid simulations.

Finite volume FE-based thermal solver technology to efficiently simulate complex heat transfer phenomena

The Femap Thermal solver features high order finite volume FE-based technology to accurately and efficiently simulate heat transfer phenomena. It combines the versatility of FE-based analysis with the accuracy and efficiency of a finite-difference scheme. Femap Thermal solver technology facilitates simulation of Femap parts and assemblies within complex thermal environments. Its solver and modeling features include:

Solver capabilities

- Steady-state (linear and nonlinear)
- Transient (linear and nonlinear)
- Material nonlinear thermal properties
- Axisymmetric modeling
- Cyclic thermal simulation
- High speed rotational effects
- Iterative conjugate gradient solver technology
- Fully coupled conduction, radiation and convection heat transfer simulation
- Electrical joule heating
- Ray-tracing including ray extinction and heat dissipation within participating media
- Latent heat of material phase changes and thermal ablation modeling
- 1D hydraulic networks for explicit thermo-fluid couplings

Enhanced thermal coupling capabilities: One-way and user functions

- Thermally connect disjoint and dissimilar mesh faces and edges
- Surface-to-surface, edge-to-edge and/or edge-to-surface contact modeling between parts: constant time or temperature-dependent coefficient of heat transfer, resistances or conductance
- Radiative exchange between disjoint part faces and faces within a single part

Femap Advanced Thermal Solver

Features

- Thermal couplings for joining disjoint solid or surface meshes within an assembly
- Thermo-fluid interactions when coupled with Femap Flow
- Fast and accurate FE-based finite volume thermal and heat transfer solver
- Most complete toolset for advanced thermal radiation modeling
- Electrical heating
- Diurnal environmental and solar heating
- Material phase changes including latent heat and thermal ablation modeling
- Interface modeling between connected parts: constant, time or temperature dependent coefficient of heat transfer, resistance or conductance
- Convective exchange correlations between faces: parallel plates, concentric spheres or cylinders

Applied heat loads

- Constant and time-dependent heat loads
- Constant and time-dependent heat flux
- Constant and time-dependent heat generation
- All applied loads controlled with temperature-controlled thermostat conditions or PID controllers

Temperature boundary conditions

- Constant temperature for steady-state or transient
- Time varying for transient and for nonlinear steady-state
- Thermostat temperature controls

Conduction heat transfer

- Ability to handle large conduction heat transfer models (memory efficient data scheme)
- Temperature-dependent conductivity
- Temperature-dependent specific heat
- Orthotropic conductivity
- Heat of formation at phase change temperature

Convection heat transfer

- Constant, time and temperature-dependent heat transfer coefficients
- Parameter and nonlinear temperature gradient functions
- Free convection
- Correlation-based free convection to ambient for inclined plates, cylinders and spheres
- Forced convection
- Correlation-based convection for plates, spheres and cylinders in forced fluid flow

Radiation heat transfer

- Constant and temperature-dependent emissivity
- Multiple radiation enclosures
- Diffuse view factor calculations with shadowing
- Net view factor calculations
- Adaptive scheme for view factor sum optimization
- Hemicube-based view (form) factors calculation using graphics card hardware
- Radiation patch generation to condense large element-based radiation models
- Submodeling capabilities
- Radiation matrix controls and parameters
- Advanced optical properties (wavelength dependent, etc.)
- Monte Carlo method for advanced ray tracing and scattering in participating media

Initial conditions

- Starting temperatures for both steady-state and transient
- Starting temperatures from previous solution results, from file

Solver and solution attributes

- Improved adaptive time stepping
- Restart conditions, cyclic convergence criteria
- Direct access to solver parameters
- Solver convergence criteria and relaxation factors
- Solver monitor with solution convergence and attributes
- Intermediate results display and recovery directly from solver progress monitor

Other features

- Results Reporter
- Summary of results to Excel worksheets
- Heat flow calculation between groups
- Heat maps
- Complete or partial deactivation of selected elements (for radiation view factor calculations)
- User subroutines
- Initial conditions from dissimilar meshes
- Thermostat and active heater controller reports
- Enhanced transient end time options
- Hydraulic network enhancements
- Improved duct flow advection scheme
- Duct-to-3D-CFD connections
- Execute up to eight processes on a compute node via distributed memory parallelization (DMP)
- Enhanced Orbit Visualizer
- Preview orbit, spacecraft orientation, and calculation points
- Rich set of visualization options

Simulation results

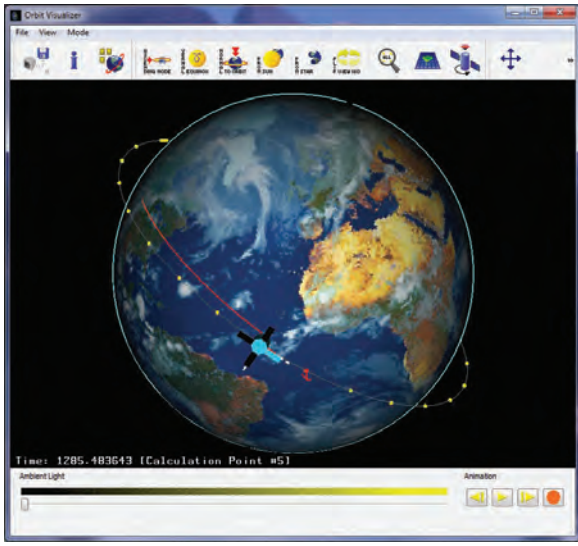
The results list has been updated.
The following results are now available:

- Thermal:
  - Temperatures
  - Min/max temperatures and occurence times
  - Total temperatures
  - Conductive heat fluxes
  - Convective heat fluxes
  - Temperature gradients
  - Transverse temperature gradients
  - Total loads and fluxes
  - Residuals
  - Free and forced convection coefficients
  - Joule data
  - Phase change quality
  - RC products
- Radiation:
  - View factor sums
  - Environmental view factors
  - Apparent temperatures
  - Radiances
  - Fluences
  - Net radiative fluxes
  - Radiosity fluxes
  - Irradiance fluxes
- Orbital and radiative source fluxes:
  - Solar and planet view factors
  - Absorbed fluxes
  - Incident fluxes
  - Transmitted fluxes
  - Reflected fluxes
- 1D flow:
  - Temperatures
  - Velocities
  - Swirl velocities
  - Pressures
  - Densities
  - Mass flows
  - Reynolds numbers

Features

Thermal couplings for joining disjoint solid or surface meshes

Thermal couplings provide a powerful and efficient capability for building assemblies by modeling heat flow between unconnected parts, components or even dissimilar meshes. Multiple what-if scenarios and positioning of parts within an assembly can be investigated by defining the thermal coupling parameters between unconnected parts only once. Heat transfer paths are automatically created between elements on opposing parts at



runtime. These conductances are established based on proximity; in addition, they account for overlap and mismatch between disjoint and dissimilar meshes exchanging heat, allowing parts to be moved freely within the assembly prior to running the analysis. Thermal coupling types include conductive, radiative, convective and interface couplings. Thermal couplings can also be defined as varying with different model parameters such as temperatures or heat loads.

Thermo-fluid and thermo-elastic interactions

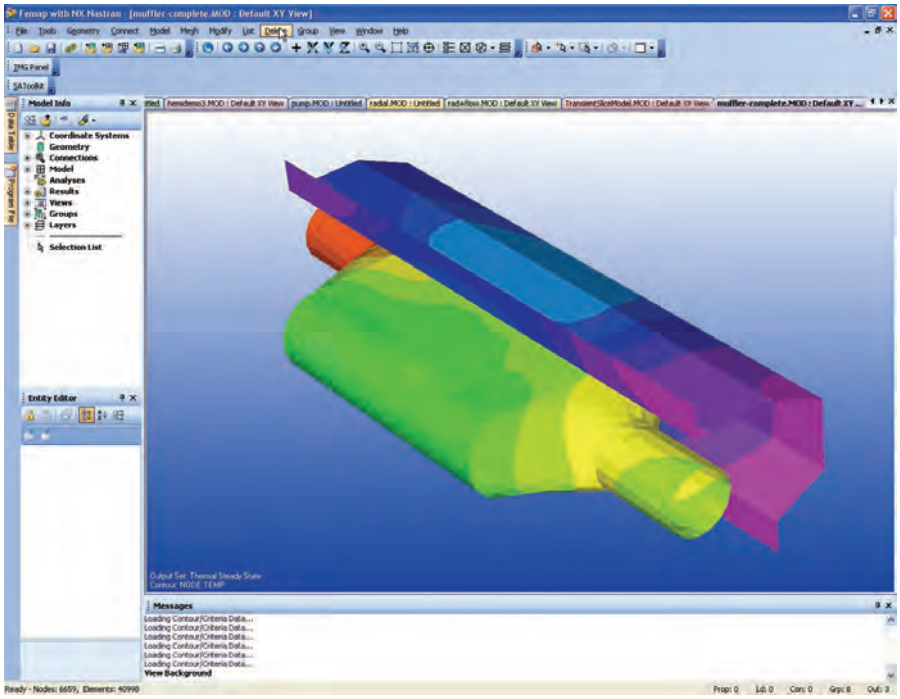
Advanced heat transfer modeling capabilities can be explicitly combined with the Femap Flow computational fluid dynamics (CFD) solution. This combination allows a user to simulate strong and fully-coupled thermo-fluid interactions problems, including complex radiative heat transfer. When licenses of Femap Flow and Femap Thermal and Femap Advanced Thermal are purchased together, the thermo-fluid solver is automatically turned on at no additional cost, offering both conduction and radiation modeling to be fully coupled with 3D fluid flow.

Integrated thermal and heat transfer solution

Femap Advanced Thermal is integrated within the Femap portfolio and takes full advantage of the Femap advanced simulation environment. The Femap integrated application allows both skilled engineers and thermal specialists to avoid any additional transfer of input files or geometry conversions and manipulations breaking the associative link between Femap geometry and FE tasks.

The Femap interface provides Femap Advanced Thermal users with a broad set of tools for creating thermal models and analysis-ready geometry. A user can automatically (or manually) remove unnecessary geometrical features. The user can refine the mesh in critical areas and selectively control mesh density, minimizing or optimizing model size for rapid and accurate solution.

By virtue of being native to the Femap environment, Femap Advanced Thermal provides the ability to model, catalog and share parts and material libraries among the design team, thereby minimizing tedious rework and potentially costly modeling errors.



Product availability

Femap Advanced Thermal is a module in the suite of advanced simulation applications available within the Femap product configuration. When used with Femap Flow, Femap Advanced Thermal provides a coupled multi-physics solution for complex fluid flow and complex thermal interaction applications.

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