

Heat Transfer Modeling

Introductory FLUENT Training

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ANSYS FLUENT*

Outline

- Energy Equation
- Wall Boundary Conditions
- Conjugate Heat Transfer
- Thin and two-sided walls
- Natural Convection
- Radiation Models
- Reporting Export



Energy Equation – Introduction

• Energy transport equation:

$$\frac{\partial(\rho E)}{\partial t} + \nabla \cdot \left[\vec{V} (\rho E + p) \right] = \nabla \cdot \left[k_{\text{eff}} \nabla T - \sum_{j} h_{j} J_{j} + \left(\overline{\overline{\tau}}_{\text{eff}} \cdot \vec{V} \right) \right] + S_{h}$$
Conduction Species Viscous Diffusion Dissipation

• Energy *E* per unit mass is defined as:

$$E = h - \frac{p}{\rho} + \frac{V^2}{2}$$

• Pressure work and kinetic energy are always accounted for with compressible flows or when using the density-based solvers. For the pressure-based solver, they are omitted and can be added through the text command:

Define/models/energy?

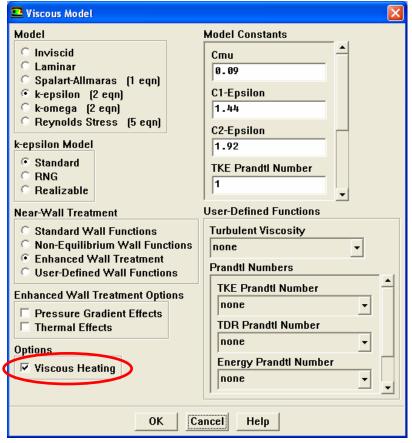
Energy Equation Terms – Viscous Dissipation

Energy source due to viscous dissipation:

 $\nabla \cdot \left(\overline{\overline{\tau}}_{\rm eff} \cdot \overrightarrow{V} \right)$

- Also called viscous heating.
- Important when viscous shear in fluid is large (e.g. lubrication) and/or in high-velocity compressible flows.
- Often negligible
 - Not included by default in the pressure-based solver.
 - Always included in the densitybased solver.
- Important when the Brinkman number approaches or exceeds unity:

$$\mathrm{Br} = \frac{\mu U_e^2}{k\,\Delta T}$$





Energy Equation Terms – Species Diffusion

• Energy source due to species diffusion included for multiple species flows.

 $abla \cdot \left(\sum_{j} h_{j} J_{j}\right)$

- Includes the effect of enthalpy transport due to species diffusion
- Always included in the densitybased solver.
- Can be disabled in the pressurebased solver.

| Species Model | |
|--|--|
| Model Off Species Transport Non-Premixed Combustion | Mixture Properties Mixture Material methane-air Tedit |
| Premixed Combustion Partially Premixed Combustion Composition PDF Transport | Number of Volumetric Species 5 Turbulence-Chemistry Interaction |
| Reactions ✓ <u>Volumetric</u> □ Wall Surface □ Particle Surface | Laminar Finite-Rate Finite-Rate/Eddy-Dissipation Eddy-Dissipation EDC |
| Options Inlet Diffusion | |
| Diffusion Energy Source Full Multicomponent Diffusion Thermal Diffusion Stiff Chemistry Solver KINetics from Reaction Design | |
| ОК Аррі | y Cancel Help |



Energy Equation Terms (3)

- Energy source due to chemical reaction is included for reacting flows.
 - Enthalpy of formation of all species.
 - Volumetric rate of creation of all species.
- Energy source due to radiation includes radiation source terms.
- Interphase energy source:
 - Includes heat transfer between continuous and discrete phase
 - DPM, spray, particles...

$$\frac{\partial(\rho E)}{\partial t} + \nabla \cdot \left[\vec{V} (\rho E + p) \right] = \nabla \cdot \left[k_{\text{eff}} \nabla T - \sum_{j} h_{j} J_{j} + \left(\overline{\overline{\tau}}_{\text{eff}} \cdot \vec{V} \right) \right] + S_{h}$$

Energy Equation for Solid Regions

• Ability to compute conduction of heat through solids

• Energy equation:
$$\frac{\partial(\rho h)}{\partial t} + \nabla \cdot (\overrightarrow{V} \rho h) = \nabla \cdot (k \nabla T) + S_h$$

• H is the sensible enthalpy:

$$h = \int_{T_{\rm ref}}^{T} c_p \, dT$$

 Anisotropic conductivity in solids (pressure-based solver only)

$$\nabla \cdot (k_{ij} \, \nabla T)$$

| Name | Material Type | Order Materials By |
|------------------------------|-------------------------------------|-------------------------------------|
| aluminum | solid | ▼ Name |
| Chemical Formula | Fluent Solid Materials | C Chemical Formula |
| al | aluminum (al) | Fluent Database |
| | Mixture | User-Defined Database |
| | none | * |
| Properties | | |
| Density (kg/m3) | constant - Edit | • |
| | 2719 | |
| Cp (j/kg-k) | constant 👻 Edit | |
| | 871 | |
| Thermal Conductivity (w/m-k) | biaxial 👻 Edit | |
| | biaxial cyl-orthotropic orthotropic | |
| | anisotropic 🛛 🔽 | |



Wall Boundary Conditions

- Five thermal conditions—
- Radiation
 - Heat transfer from exterior of model
 - Requires external emissivity and external radiation temperature.
- Mixed
 - Combined Convection and External Radiation Boundary Conditions
- Wall material and thickness can be defined for 1D or shell conduction calculations. heat transfer calculations.

| | Wall | | | X |
|---|-----------------------------|-----------------------|----------------|------------------|
| | Zone Name | | 1 | |
| | wall-17 | | | |
| | Adjacent Cell Zone | | | |
| | mrfzone | | | |
| | Momentum Thermal | Radiation Species DPM | Multiphase UDS | |
| | Thermal Conditions | | | |
| | Heat Flux | Heat Flux | : (w/m2) 0 | constant 👻 |
| | C Temperature | | Wall Thickn | ess (ft) 0 |
| | C Convection C Radiation | Heat Constantion Date | | |
| | C Mixed | Heat Generation Rate | (wimp) 0 | constant 🗾 |
| | Material Name | | | Shell Conduction |
| | aluminum | ▼ Edit | | |
| | Jarannian | | | |
| | | | | |
| | | | | |
| | | | | |
| , | | | | |
| | | | | |
| | | ОК С | ancel Help | |



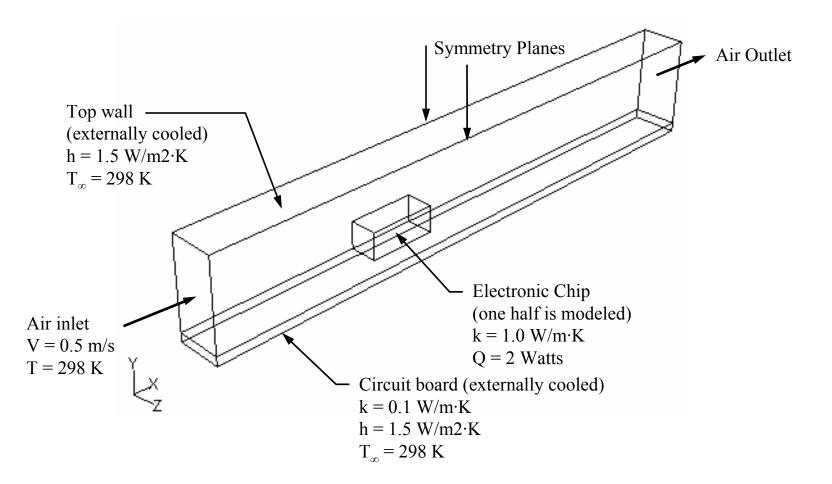
Conjugate Heat Transfer

- Ability to compute conduction of heat through solids, coupled with convective heat transfer in fluid.
- The Coupled boundary condition is available to any wall zone which separates two cell zones.

| Wall Zone Name internal-wall Adjacent Cell Zone Fluid Shadow Face Zone internal-wall-shadow | Grid |
|---|---|
| Momentum Thermal Radiation Species DPM Multiphase UDS Thermal Conditions | Velocity vectors |
| OK Cancel Help | Temperature contours Example Cooling Flow over Fuel Rods |



Conjugate Heat Transfer Example

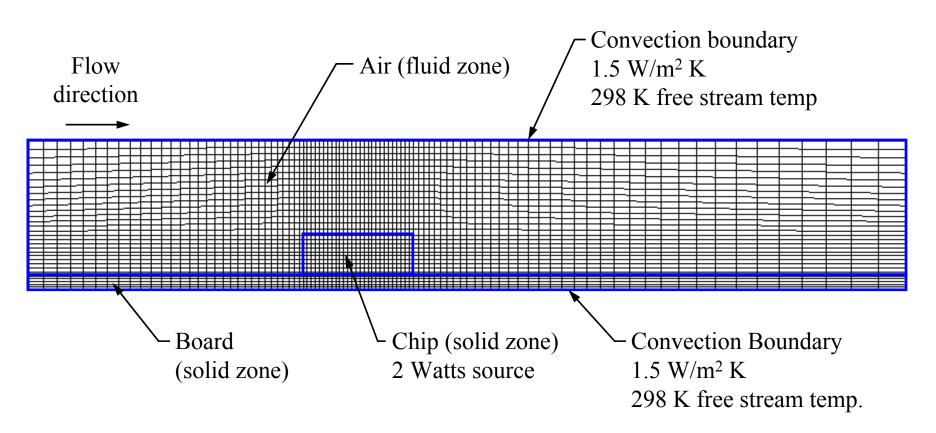


Fluent User Services Center

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Example – 3D Mesh and BC's



Fluent User Services Center

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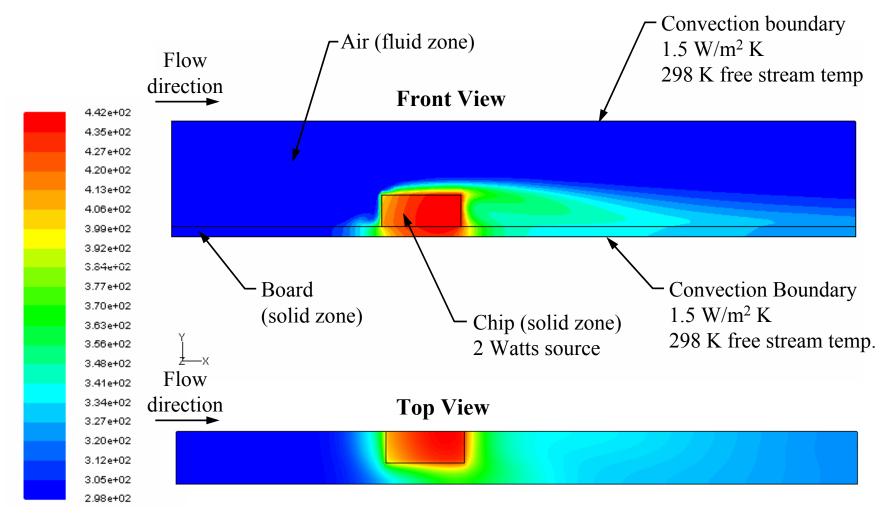


Problem Setup – Heat Source

| Solid 🔀 | |
|----------------------------------|-----------------------------------|
| Zone Name | |
| solid-chip | |
| Material Name chip 🗾 Edit | Energy (w/m3) sources |
| ✓ Source Terms Fixed Values | Number of Energy (w/m3) sources 1 |
| Motion Source Terms Fixed Values | 1. 904055 constant 💌 |
| Energy (w/m3) 1 source Edit | |
| ▼ | OK Cancel Help |
| | |
| OK Cancel Help | |



Temperature Distribution (Front and Top View)





Conjugate Heat Transfer Setup

| Name fuid 1i fuid Chemical Formulas Fuent Fluid autors in Fluent Fl | Materials | | | Fluid 🛛 |
|---|---------------------------------------|------------------------|--------------------------|--|
| Circlenteral Pointura Fluent Prutent Prutent Materials Fluent Database Portrous Zeae Properties Solid Source Terms Source Terms Density [kg/m3] incompressible-ideal-gas Material Name chip Idit Fixed Values Cp [j/kg-k] Constant Source Terms Fixed Values Motion Source Terms Fixed Values Image: Source Terms Fixed Values Y @ Viscosity [kg/m-s] constant Energy (w/m3] i sources OK Number of Energy (w/m3] sources OK Cancel Help | | | ▼ • Name | |
| Mixture Solid Properties Solid-chip Density (kg/m3) incompressible-ideal-gas Material Name chip dit V Source Terms Fixed Values Rotation-Axis Origin Rotation-Axis Direction V Source Terms Fixed Values Motion Source Terms V Source Terms Fixed Values Motion Sources OK Cancel Help Viscosity (kg/m-s) constant 1.7894e-05 Image: Constant 1.9940955 constant | Chemical Formula | | <u> </u> | |
| Density (kg/m3) incompressible-ideal-gas Material Name chip Idit Cp (j/kg-k) constant Fixed Values 1006.43 Motion Source Terms Fixed Values Thermal Conductivity (w/m-k) constant 0.0242 Energy (w/m3) 1 source Viscosity (kg/m-s) constant 1.7894e-05 I.994055 | Properties | none Sol | ne Name | ☐ Source Terms ☐ Fixed Values |
| Cp (j/kg-k) constant 1006.43 Thermal Conductivity (w/m-k) constant 0.0242 Viscosity (kg/m-s) constant 1.7894e-05 I.984055 Constant Viscosity (kg/m-s) constant 1.7894e-05 I.984055 Constant Viscosity (kg/m-s) constant I.984055 Constant Viscosity (kg/m-s) Constant I.984055 Constant I.984055 Constant | Density (kg/m3) inc | compressible-ideal-gas | aterial Name chip 🔹 Edit | Rotation-Axis Origin Rotation-Axis Direction |
| Ø. 8242 Viscosity (kg/m-s) constant 1.7894e-05 1.9848055 constant | · · · · · · · · · · · · · · · · · · · | nstant | Fixed Values | |
| Viscosity [kg/m-s] constant 1.7894e-05 1.904055 constant 1.904055 constant | | | , | Motion Type Stationary |
| | | | | OK Cancel Help |
| OK Cancel Help | 1 | | | |



Alternate Modeling Strategies

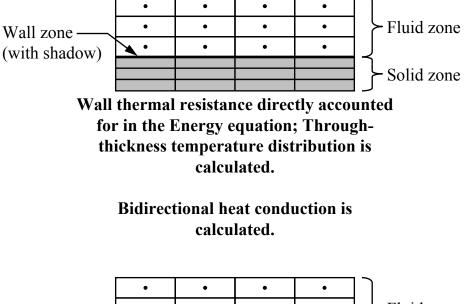
- An alternate treatment of the board surface would be to model it as a wall with specified thickness (Thin Wall model).
- In this case, there would be no need to mesh the lower solid zone (representing the board).

| Wall | | | | | | |
|---|-----------|-----------|----------------|---|-----------------------|------------|
| Zone Name wall-board-l Adjacent Cell Z solid-board | | | | - | | |
| | Thermal | Radiation | Species DPM | Multiphase UDS | 1 | 1 |
| Thermal Cond C Heat Flux C Temperat C Convection | c ture | | | icient (w/m2-k) 1.5 emperature (k) 298 | constant constant | • |
| © Radiation © Mixed | | | Heat Generatio | Wa on Rate (w/m3) 👩 | II Thickness (in) 0.1 | |
| Material Nam aluminum | e | ▼ Edit | | | Shell Condu | uction |
| | | | OK | Cancel Help | | |

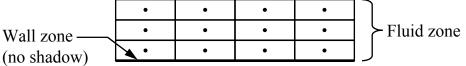
Two Approaches for Wall Heat Transfer

• Meshed wall

- Energy equation is solved in a solid zone representing the wall.
- Wall thickness must be meshed.
- This is the most accurate approach but requires more meshing effort.
- Always uses the coupled thermal boundary condition since there are cells on both sides of the wall.



- Thin wall
 - Artificially models the thickness of the wall (specified on the wall BC panel).
 - Uses the coupled thermal boundary condition only for internal walls.

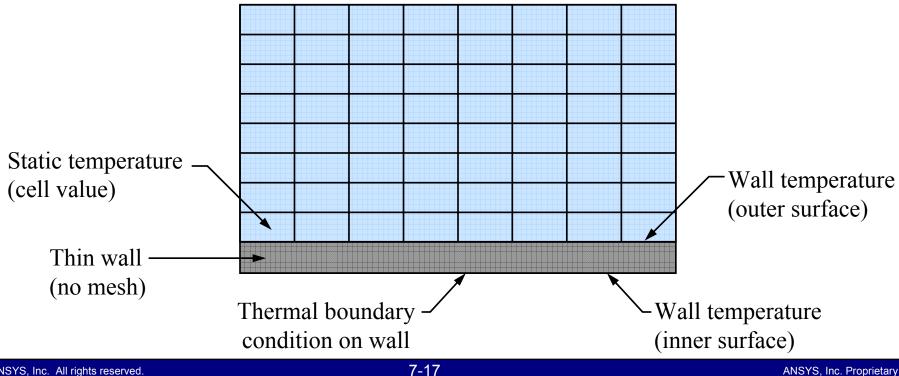


Wall thermal resistance calculated using artificial wall thickness and material type. Through-thickness temperature distribution is assumed to be linear.

Conduction only calculated in the wallnormal direction.

Temperature Definitions for Thin Wall Model

- Thin wall model applies normal conduction only (no in-plane conduction) and no actual cells are created.
- Wall thermal boundary condition is applied at the outer layer





Shell Conduction Option for Wall Heat Transfer

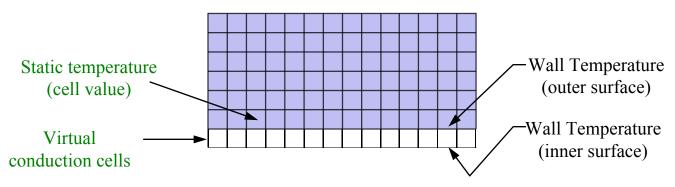
Wall

- The shell conduction option is used to enable in-plane conduction calculations.
- Additional conduction cells are created but can not be displayed and cannot be accessed by UDFs.

Solid properties of the

| Zone Name | | | | |
|---|-----------------------|-------------------|-------------------|------|
| wall-board-bottom | | | | |
| Adjacent Cell Zone | | | | |
| solid-board | | | | |
| Momentum Thermal | Radiation Species DPM | Multiphase UDS | | |
| Thermal Conditions | | | | |
| C Heat Flux | Heat Transfer Coeffic | ient (w/m2-k) 1.5 | constant | - |
| Temperature Convection | Free Stream Te | nperature (k) 298 | constant | • |
| C Radiation | | Wall T | hickness (in) 0.1 | |
| Material Name | Heat Generation | Rate (w/m3) | constant | • |
| aluminum | ▼ Edit | | Shell Conduc | tion |
| | ОК | Cancel Help | | |

conduction zones must be constant and can not be specified as temperature-dependent.

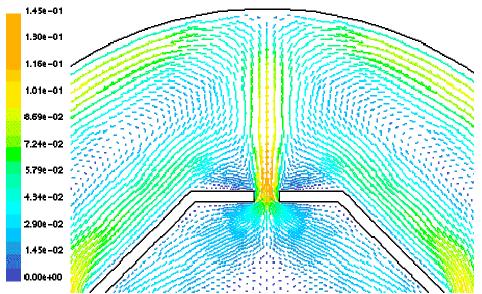


Natural Convection – Introduction

- Natural convection occurs when heat is added to fluid and fluid density varies with temperature.
- Flow is induced by force of gravity acting on density variation.
- When gravity term is included, pressure gradient and body force term in the momentum equation are re-written as:

$$-\frac{\partial p}{\partial x} + \rho g \Longrightarrow -\frac{\partial p'}{\partial x} + (\rho - \rho_0)g$$

where
$$p' = p - \rho_0 g x$$



• This format avoids potential roundoff error when gravitational body force term is included.

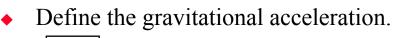
Natural Convection – the Boussinesq Model

• Boussinesq model assumes the fluid density is uniform except for the body force term in the momentum equation along the direction of gravity, we have:

$$(\rho - \rho_0)g = -\rho_0\beta(T - T_0)g$$

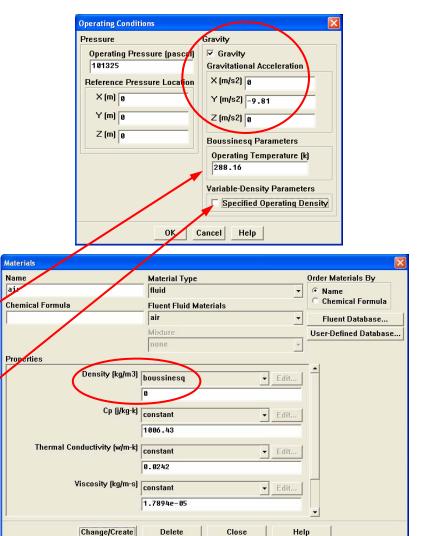
- Valid when density variations are small (i.e., small variations in *T*).
- It provides faster convergence for many natural-convection flows than by using fluid density as function of temperature.
 - Constant density assumptions reduces non-linearity.
 - Suitable when density variations are small.
 - Cannot be used together with species transport or reacting flows.
- Natural convection problems inside closed domains:
 - For steady-state solver, Boussinesq model must be used.
 - The constant density, ρ_0 , properly specifies the mass of the domain.
 - For unsteady solver, Boussinesq model or ideal gas law can be used.
 - Initial conditions define mass in the domain.

User Inputs for Natural Convection



Define Operating Conditions...

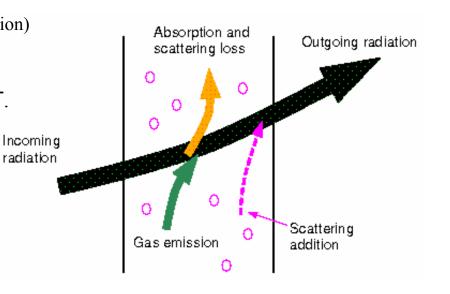
- Define density model.
 - If using Boussinesq model:
 - Select boussinesq as the Density method and assign constant value, ρ₀.
 Define → Materials...
 - Set Thermal Expansion Coefficient, β.
 - Set Operating Temperature, T₀.—
 - If using a temperature-dependent model, (e.g., ideal gas or polynomial):
 - Specify Operating Density or,
 - Allow FLUENT to calculate ρ₀ from a cell average (default, every iteration).



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Radiation

- Radiation effects should be accounted for when $Q_{rad} = \sigma (T_{max}^4 T_{min}^4)$ is of equal or greater magnitude than that of convective and conductive heat transfer rates.
- To account for radiation, radiative intensity transport equations (RTEs) are solved.
 - Local absorption by fluid and at boundaries couples these RTEs with the energy equation.
- Radiation intensity, I(r,s), is directionally and spatially dependent.
- Transport mechanisms for radiation intensity:
 - Local absorption
 - Out-scattering (scattering away from the direction)
 - Local emission
 - In-scattering (scattering into the direction)
- Five radiation models are available in FLUENT.
 - Discrete Ordinates Model (DOM)
 - Discrete Transfer Radiation Model (DTRM)
 - P1 Radiation Model
 - Rosseland Model
 - Surface-to-Surface (S2S)



Discrete Ordinates Model

• The radiative transfer equation is solved for a discrete number of finite solid angles, σ_s :

 $\frac{\partial I}{\partial x_i} + \underbrace{\left(a + \sigma_s\right)I(r, s)}_{\text{Absorption}} = a n^2 \frac{\sigma T^4}{\pi} + \underbrace{\frac{\sigma_s}{4\pi} \int_0^{4\pi} I(r, s') \Phi(s \cdot s') d\Omega'}_{\text{Emission}}$

- Advantages:
 - Conservative method leads to heat balance for coarse discretization.
 - Accuracy can be increased by using a finer discretization.
 - Most comprehensive radiation model:
 - Accounts for scattering, semi-transparent media, specular surfaces, and wavelength-dependent transmission using banded-gray option.
- Limitations:
 - Solving a problem with a large number of ordinates is CPU-intensive.

Discrete Transfer Radiation Model (DTRM)

- Main assumption Radiation leaving a surface element within a specified range of solid angles can be approximated by a single ray.
- Uses a ray-tracing technique to integrate radiant intensity along each ray:

$$\frac{dI}{ds} + a I = \frac{a \,\sigma T^4}{\pi}$$

- Advantages:
 - Relatively simple model.
 - Can increase accuracy by increasing number of rays.
 - Applies to wide range of optical thicknesses.
- Limitations:
 - Assumes all surfaces are diffuse.
 - Effect of scattering not included.
 - Solving a problem with a large number of rays is CPU-intensive.



P-1 Model

- Main assumption The directional dependence in RTE is integrated out, resulting in a diffusion equation for incident radiation.
- Advantages:
 - Radiative transfer equation easy to solve with little CPU demand.
 - Includes effect of scattering.
 - Effects of particles, droplets, and soot can be included.
 - Works reasonably well for applications where the optical thickness is large (e.g. combustion).
- Limitations:
 - Assumes all surfaces are diffuse.
 - May result in loss of accuracy (depending on the complexity of the geometry) if the optical thickness is small.
 - Tends to overpredict radiative fluxes from localized heat sources or sinks.



Surface-to-Surface Radiation Model

- The S2S radiation model can be used for modeling radiation in situations where there is no participating media.
 - For example, spacecraft heat rejection system, solar collector systems, radiative space heaters, and automotive underhood cooling.
 - S2S is a view-factor based model.
 - Non-participating media is assumed.
- Limitations:
 - The S2S model assumes that all surfaces are diffuse.
 - The implementation assumes gray radiation.
 - Storage and memory requirements increase very rapidly as the number of surface faces increases.
 - Memory requirements can be reduced by using clusters of surface faces.
 - Clustering does not work with sliding meshes or hanging nodes.
 - Not to be used with periodic or symmetry boundary conditions.

Introductory FLUENT Notes FLUENT v6.3 December 2006



Solar Load Model

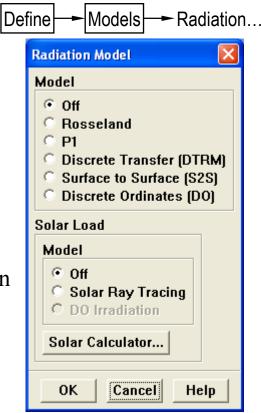
- Solar load model
 - Ray tracing algorithm for solar radiant energy transport: Compatible with all radiation models
 - Available with parallel solver (but ray tracing algorithm is not parallelized)
 - 3D only
- Specifications
 - Sun direction vector
 - Solar intensity (direct, diffuse)
 - Solar calculator for calculating direction and direct intensity using theoretical maximum or "fair weather conditions"
 - Transient cases
 - When direction vector is specified with solar calculator, sun direction vector will change accordingly in transient simulation
 - Specify "time steps per solar load update"

| | | Solar Calculator | | |
|---|--|---|---|--|
| | | Global Position Grid Orientation | | |
| | | Longitude (deg) -84.62999 North East | | |
| | | Latitude (deg) 13.65 | | |
| | Radiation Model | Timezone (+-GMT) -5 | | |
| | Model | | | |
| | Off | Date and Time Solar Irradiation Method | | |
| | C Rosseland | Day of Year Time of Day C Theoretical Maximum | | |
| | 0 P1 | Day 21 Hour 13 | | |
| | Discrete Transfer (DTRM) Surface to Surface (\$2\$) | 1 Month & A Minute e | _ | |
| | C Discrete Ordinates DO | Sunshine Factor 1 | | |
| | · · · · · | Apply Close Help | | |
| | Solar Load | | | |
| | Model Su | n Direction Vector | | |
| | <u>C</u> Off X | | | |
| 1 | 📀 Solar Ray Tracing | Use Direction Computed from Solar Calculator | | |
| | | | | |
| | Solar Calculator | mination Parameters | | |
| | | Direct Solar Irradiation (w/m2) constant 👻 Edit | | |
| | | | | |
| | | 1423 | | |
| | D | iffuse Solar Irradiation (w/m2) constant 👻 Edit | | |
| | | | | |
| | | 200 | | |
| | | Spectral Fraction [V/(V+IR)] 0.5 | | |
| | | | | |
| | | | | |
| | | OK Cancel Help | | |



Choosing a Radiation Model

- For certain problems, one radiation model may be more appropriate in general.
 - Computational effort P1gives reasonable accuracy with less effort.
 - Accuracy DTRM and DOM more accurate.
 - Optical thickness DTRM/DOM for optically thin media ($\alpha L \ll 1$); P1 better for optically thick media.
 - Scattering P1 and DOM account for scattering.
 - Particulate effects P1 and DOM account for radiation exchange between gas and particulates.
 - Localized heat sources DTRM/DOM with sufficiently large number of rays/ ordinates is more appropriate.

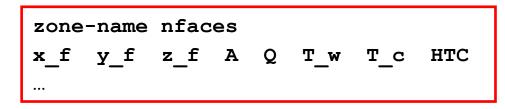


Reporting – Heat Flux

- Heat flux report:
 - It is recommended that you perform a heat balance check to ensure that your solution is truly converged.
- Exporting Heat Flux Data:
 - It is possible to export heat flux data on wall zones (including radiation) to a generic file.
 - Use the text interface:

file/export/custom-heat-flux

• File format for each selected face zone:



| LS -M Flux Reports | | | | | | |
|--|---|--|--|--|--|--|
| Options Mass Flow Rate Total Heat Transfer Rate Radiation Heat Transfer Rate Boundary Types axis exhaust-fan fan inlet-vent Boundary Name Pattern | Boundaries internal-3 pressure-outlet-7 velocity-inlet-5 velocity-inlet-6 wall-4 wall-8 | Results -4599548.5 -1764784 6360935.5 0 0 | | | | |
| Match | , | w -3397 | | | | |
| Compute | Compute Close Help | | | | | |



Reporting – Heat Transfer Coefficient

• Wall-function-based HTC

$$h_{\rm eff} = \frac{\rho C_P C_{\mu}^{1/4} k_P^{1/2}}{T^*}$$

where C_P is the specific heat, k_P is the turbulence kinetic energy at point P, and T^{*} is defined in Chapter 13 of the FLUENT 6.3 User Guide.

- Available only when the flow is turbulent and Energy equation is enabled
- Alternative for cases with adiabatic walls.





- There are many introductory level tutorials which use concepts discussed in this lecture.
 - Periodic Flow and Heat Transfer (Tutorial #2)
 - Radiation and Natural Convection (Tutorial #5)
 - Solidification (Tutorial #20)
 - Many others...
- A number of intermediate and advanced tutorials are also available at www.learningcfd.com/login/fluent/intermediate/tutorials/index.htm
- Other learning resources
 - Advanced training course in heat transfer offered by FLUENT
 - Web-based training modules
 - User Services Center, www.fluentusers.com
 - All tutorials and lecture notes
 - User Documentation

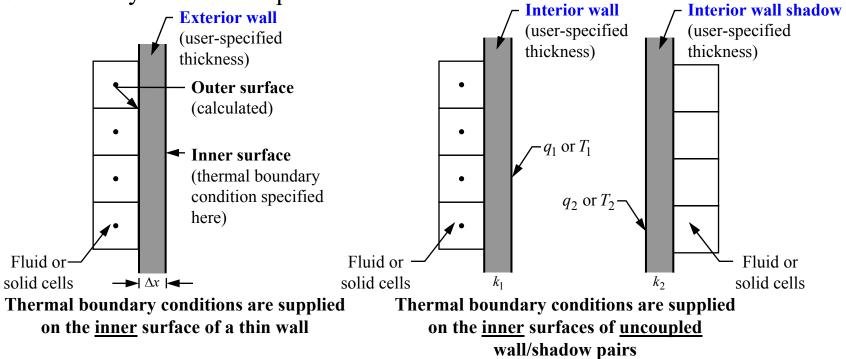


Appendix

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Thin and Two-Sided Walls

- In the Thin Wall approach, the wall thickness is not explicitly meshed.
- Model thin layer of material between two zones
- Thermal resistance $\Delta x/k$ is artificially applied by the solver.
- Boundary conditions specified on the outside surface.



Export – ANSYS

• Export ANSYS file through GUI or TUI:

file/export/ansys file-name

- A single file will be written containing coordinates, connectivity, and the scalars listed below:
 - x-velocity, y-velocity, z-velocity, pressure, temperature,
 - turb-kinetic -energy, turb-diss-rate, density, viscosity-turb, viscosity-lam, viscosity-eff, thermal-conductivity-lam, thermal-conductivity-eff,
 - total-pressure, total-temperature, pressure-coefficient, mach-number, stream-function,
 - heat-flux, heat-transfer-coef, wall-shear, specific-heat-cp

| ABAQUS | Surfaces 🔳 🗮 | Functions to Write | |
|------------------------|--|---|--|
| ANSYS | default-interior default-interior:001 | Static Pressure Pressure Coefficient | |
| ASCII | inlet | Dynainíc Pressure | |
| AVS | inlet-cyl int-hole | Absolute Pressure Total Pressure | |
| CGNS | int-wall | Relative Total Pressure | |
| > Data Explorer | outlet | Density | |
| EnSight 6 | sym1 sym2 | Density All Velocity Magnitude | |
| EnSight Case Gold | wall | × Velocity | |
| FAST | wall-16 wall-17 | Y Velocity Z Velocity | |
| FAST Solution | wall-cyl | Axial Velocity | |
| Fieldview Unstructured | X=Q | Radial Velocity Tangential Velocity | |
| Fieldview Case+Data | | Relative Velocity Magnitude | |
| Fieldview Data | Loads | | |
| I-DEAS Universal | 🗖 Force | | |
| NASTRAN | 🖵 Temperature | | |
| PATRAN | 🖵 Heat Flux | | |
| RadTherm | J | | |
| Tecplot | | | |



Export – ANSYS

- The file written is an ANSYS results file with a .rfl extension. To read this file into ANSYS, use the following procedure:
 - 1. In ANSYS, go to General Postproc Data and File Options and read the .rfl file generated from FLUENT.
 - 2. Go to Results Summary and click on the first line in the upcoming panel. You will see some information listed in the ANSYS_56_OUTPUT window displaying geomtery informatiom.
 - 3. In the small ANSYS Input window, enter the following commands in order:

SET, FIRST

/PREP7

ET,1,142

The last command corresponds to FLOTRAN 3D element. If your case is 2D, then this should be replaced by "**ET**, **1**, **141**".

4. In the ANSYS MULTIPHYSICS UTITLITY menu, select Plot and then Nodes or Elements, including the nodal solution under Results in the drop-down list.



Export – ABAQUS

- A single file (e.g., file.aba) containing coordinates, connectivity, optional loads, zone groups, velocity, and selected scalars will be written. You can specify which scalars you want in the Functions to Write list.
- Export of data to Abaqus is available only for 3D models and is valid only for solid zones or for those surfaces that lie at the intersection of solid zones.
- None of the fluid zone heat transfer properties will get exported
- Ideal only when you want to do some Fluid-Solid interface i.e., wall analysis.

file/export/abaqus file-name list-of-surfaces () yes no list-of-scalars q

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Export to Other Formats

- NASTRAN/PATRAN: The best approach.
- For ABAQUS, ٠ NASTRAN, and PATRAN, select the Loads to be written (Force, Temperature, and/or Heat Flux) to analyze the structural stresses (fluid pressure or thermal) in an FEA program.
- Loads are written only on boundary walls when the entire domain is exported (i.e., if you select no Surfaces).

| File Type C ABAQUS C ANSYS Input C ASCII C AVS C CGNS C Data Explorer C EnSight Case Gold C FAST C FAST Solution C Fieldview Unstructured C I-deas Universal C NASTRAN C PATRAN C Tecplot | Surfaces E = baffle baffle-shadow default-interior:011 impeller impeller-shadow impeller:001 interface-outer shaft top wall wall-17 wall-18 | Functions to Write Static Pressure Pressure Coefficient Dynamic Pressure Absolute Pressure Relative Total Pressure Density Density All Velocity Magnitude X Velocity Y Velocity Z Velocity Radial Velocity Radial Velocity Radial Velocity Relative Velocity Magnitude Relative X Velocity Relative Z Velocity | Format Abaqus ANSYS ASCII CGNS NASTRAN PATRAN TECPLOT |
|---|---|--|--|
| Structural Loads | Location | Delimiter | TECTEOT |
| □ Force □ Pressure □ Temperature | Node Cell Center | Comma ⊂ Space | |

Supported

Version 6.3

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