Using Multilayer Shells

Use thin shells with a multilayer physical property to model any broad thin geometry (such as panels, layers, etc.) in which you want a detailed picture of the conduction through the geometry without using thin solid elements. Multilayer shells present a smaller conductance matrix than solid elements.

In a multilayer shell, the through-plane conductance is a function of thermal conductivity (material property) and layer thickness (shell thickness divided by the number of layers). The volume of the shell is evenly shared among the layers and all layers are of the same material. TMG creates a temperature calculation point for each layer and automatically connects the calculation points of adjacent layers with the appropriate conductance.

For Isotropic materials, TMG uses the Thermal Conductivity material property to calculate a conductive heat transfer coefficient between each pair of adjacent layers. For Orthotropic materials, TMG uses the *Thermal Conductivity Z* material property to create the conductive thermal couplings.

For materials with a constant thermal conductivity, all conductances will be equal between the layers. For materials with a constant specific heat, each layer will have the same capacitance. For non-linear materials, the layers may have different values.

Highly temperature-dependant material properties within the thin geometry can be accurately represented using the multilayer physical property, provided that heat flow through the plane predominates over the in-plane heat flow.

Usage

Use the same technique to create a multilayer physical property as you would to create a single layer thin shell physical property:

1. In the *Meshing* task, pick the *Physical Property Create* icon.
2. Select the *TMG/ESC* analysis program on the *Physical Property Tables* form.
3. Pick the *New Table* icon.
4. Pick *OK* on the *Select Element Type* form to accept a 2D thin shell.
5. On the *I_DEAS Thin Shell & Membrane Physical Property Table* form, enter the shell name, its total thickness and an odd number of layers.

TMG supports only odd numbers of layers. If an even number is given, TMG will add one layer.

Temperature Dependent Material Properties

Define a temperature dependent material property through Materials in the Meshing task or through *Interpolation Relationships* in the TMG task. Since the temperature is calculated for each layer, temperature dependent variation of the material properties within the surface thickness is possible. The accuracy of through-plane conduction modeling is enhanced by dividing the shell into a greater number of layers. However, more layers result in additional computational time and reduced accuracy of in-plane conduction modeling.

Conduction Calculation

In-plane conduction is calculated for the middle layer only. This is why TMG requires an odd number of layers: to ensure that there is a unique middle layer. In-plane conduction is most accurately modeled with few layers (one layer being the most accurate). When calculating in-plane conduction for a multilayer shell, TMG assigns the whole thickness of the shell to the middle layer. By calculating in-plane conduction in one layer, the numerical model is greatly simplified. This also implies that, when using multilayer shells, the through-plane heat flow should be the dominant effect over the in-plane heat flow.

Applications of Multilayer Shells

Radiation

Since elements can only radiate from their top or bottom sides, for radiation we are only concerned with the top and bottom layers of a multilayer shell. The top layer corresponds to the positive side of the surface element. If the elements radiate from both sides (that is, if a Reverse Side is created for the surface) the Reverse Side corresponds to the bottom layer and the Reverse Side material properties take precedence.

Thermal Couplings

When connecting a multilayer mesh to another mesh with a thermal coupling, the coupling is established either from the top or the bottom layer, depending on which layer is closer to the connected mesh.

Thermal Boundary Conditions

Heat loads are applied to the top layer. Temperature sinks are applied to the middle layer.

Post Processing

In the Post Processing task, on the Calculation Domain form, the user can choose which layer to display. A menu provides a choice of top, middle or bottom layer or the user can specify the layer number.
