Shadowing Checks

When calculating *black body view factors* between two elements, TMG must determine whether the view is unobstructed, partially obstructed or completely obstructed. This process of assessing the view between two elements is called *shadowing checks*.

TMG performs a series of preliminary shadowing checks to determine which method to use for calculating the view factors: Exact Contour Integral for pairs with an unobstructed view, Nusselt Sphere for pairs with partial view and no calculation for pairs that can't see each other. During initialization for this process, TMG combines adjacent co-planar elements into a single shadowing surface to reduce the number of shadowing checks.

Partial View Calculation

TMG uses the Nusselt Sphere technique to calculate black body view factors for surface pairs whose view is partially shadowed by other elements. This algorithm involves the following steps:

1. Each surface is subdivided according to a parameter specified by the user. The accuracy of the calculation is proportional to the granularity of the surface sub-division; the penalty for higher accuracy is increased computation time.

2. Shadowing checks are performed for each of the sub-surface pairs; an intervening surface is considered to shadow if it intercepts the line joining the centroids of the two sub-surfaces. If shadowing is discovered, the view factor between the two sub-surfaces is set to 0.

3. The view factors are calculated between unshadowed sub-surface pairs only. The vertices of the larger sub-surface are first projected onto a unit sphere centered at the centroid of the smaller sub-surface (*by drawing lines from the vertices of the bigger surface to the sphere center)*; from there, they are re-projected onto the plane of the smaller sub-surface. The area of this projected surface is equal to the view factor.

4. The view factors for all sub-surface pairs are summed to obtain the overall view factor.

Calculation of view factors can be a very intensive process: for a model with n radiating surfaces, the number of shadowing checks to be performed is proportional to n^3.

How to Check View Factors

Within an enclosure, the sum of any element's black body view factors should equal one. This is not usually the case mainly because of imprecision in the calculation of the partial views.

After an analysis, you must verify that your model yields good *element view factor sums*. TMG calculates the element view factor sums of each element participating in a *Radiation Request* and also computes the *element view factor residual* for these elements:

Element View Factor Residual = 1 - Element View Factor Sum

Values of element view factor sums between 0.90 and 1.05 are acceptable. Bigger discrepancies are indicators of problems with the model. TMG always reports the minimum and maximum element view factor sums and issues a warning message during calculation if at least one element view factor sum is less than 0.80 or greater than 1.20.

All element view factor sums and element view factor residuals are reported in the file REPF with their corresponding element label.

Carefully review the element view factor sums after a radiation simulation. Problems that can cause large element view factor residuals are:

- The enclosure is not closed: check for missing elements, element orientation, reverse sides and leaks.
- The mesh may be too coarse or the specified subdivision level too low to accurately calculate the partial views.
- The Space Enclosure is missing.

Specifying the Subdivision Level

Two methods are available to specify which level of subdivision should be performed when calculating partial views: the *Error Criterion* and the *Fixed Subdivision*.

Error Criterion

When using the *Error Criterion* option on a *Radiation Request*, the user provides the maximum acceptable element view factor residual for the element selected on the *Radiation Request.*

When solving, TMG automatically approximates, for each of these elements, a subdivision level that should yield sufficiently fine sub-elements to achieve element view factor sums that respect the criteria specified.

There is no guaranty that all element view factor sums will respect the criteria. Verify them after an analysis. If some elements are close but failed the criteria you may retry with a smaller criterion. If the discrepancies are big this may indicate a problem in the model or a mesh that is too coarse. If the mesh is too coarse, dividing with the finest subdivision may not be sufficient to achieve the required precision. In this case, the only option is to re-mesh the geometry with a finer mesh.

Error Criterion is the recommended method. Using *Error Criterion* is usually faster since elements requiring only a coarse subdivision are not needlessly subdivided.

Fixed Subdivision

With *Fixed Subdivision*, you specify the subdivision level TMG will use to subdivide the elements and calculate the partial views. All the elements of the *Radiation Request* for which shadowing has been detected will be subdivided according to the specified level.

The default when using the *Fixed Subdivision* method is the *Global Subdivision Parameter*. This parameter, defined on the *Radiation Control* form, applies to all *Radiation Requests* where *Fixed Subdivision* is selected. You can override this parameter on the *Radiation Request* form.

After the analysis, check the element view factor sums. If they differ too much from one, you can specify a higher subdivision level and solve again.

Fixed Subdivision is often used when the user wants to achieve the highest level of accuracy for the black body view factors of a specific enclosure.