1. Guidelines on creating analysis models from CAD

1.1 Introduction

In order for an analysis model to be created from CAD geometry the geometry data must be passed to the analysis system in a readable and unambiguous format. This geometry must then be converted into a volume model and the volume model must be meshed. The basic process can be split into 3 distinct tasks.

- IGES Import

- Creating Volumes

- Meshing

1.2 IGES Import

In order to enable Modeller to import CAD data from a wide range of CAD systems an IGES Import facility has been implemented. The result of an iges import can be a model consisting of a number of unconnected surfaces or, if IGES version 5 has been used, a model with volumes defined by surfaces. If a volume model is not created the points and lines should be merged from the **Geometry> Merge Geometry** menu item.

1.3 Creating Volumes

A volume can only be created from a set of closed (water tight) surfaces. This means all points and lines of adjoining surfaces must be merged. This process can cause problems because surface edges can only be joined if they lie within the merge tolerance (default 1E-6). When creating volume models, any unmerged lines may be identified by viewing the geometry by connectivity (See Geometry Layer Properties dialog) or selecting **Free edges** from connectivity option on the advanced selection dialog.. Visualising these lines can sometimes be difficult as they may be very short. Any line that is only connected to a single surface must be examined to determine why it has not merged.

Common reasons for free edges are:

- A surface has failed to import correctly and is missing. – This is identified by a closed loop of free edges (single unconnected lines). Surfaces, which have failed to import, must be either redefined in the CAD system or in Modeller.

- Adjoining points and/or lines are separated by a gap larger than the merge tolerance. – This is identified by two seemingly coincident lines, which have not merged. In some cases increasing the merge tolerance can enable unmerged points and lines to merge, but this process attempts to moves the unmerged geometry together and is not always successful. *Note: If the merge tolerance is adjusted to aid merging after import the merge tolerance should be returned to its default value of 1E-6 before carrying out geometry manipulation.*

  When lines lie outside the merge tolerance, non-planar surfaces defined by 4 lines or less and planar surfaces may be redefined by deleting the unmerged surface and defining a new surface from the selected boundary lines. It may

also be possible to redefine the boundary on non planar surfaces with more than 4 lines using **Geometry> Surface> Redefine Perimeter** but if this fails users are advised to fix such problems in their CAD system.

Note: Sometimes it is possible to break a non-planar surface defined by more than 4 lines down into 3 and 4 sided surfaces by manifolding lines onto the surface prior to deleting. The deleted surface may then be replaced with a number of new3 and 4 sided surfaces with shared edges.

- T intersections exist due to butted surfaces. – This is identified by a longer unconnected line with 2 or more coincident unconnected lines. When lines have not merged due to T-Junctions the longer line should be split using the intermediate point and the resulting lines used in the dependent geometry. This is achieved by selecting the line and intermediate point prior to choosing the **Geometry> Lines> By Splitting> At a Point** menu item with the "Use in depdendent surfaces" and "Delete lines on splitting" options selected.

1.4 Meshing

Once a volume has been defined, meshing can be carried out using tetrahedral elements. The tetrahedral meshing process will not always be successful as it depends on the quality of the surface mesh. Null line and/or null surface mesh attributes may be used to control the quality of the surface mesh where it appears distorted and the number of elements generated around holes may be controled by specifying the default angle subtended on the Meshing tab of Model Properties dialog. A good initial size for the tetrahedral mesh is to take the length of the diagonal of the model and divide it by 75. If the model is large it is often useful to cut the geometry into a number of smaller volumes using the slicing utility. Each volume can then me meshed independently before meshing to whole model.

Note: It is sometimes easier to mesh a volume with low order tetrahedral elements since the elements donot become distorted due to position of the mid side nodes. i.e. a circular hole can be meshed with a few as 3 linear elements around the circumference but many more quadratic elements are required to obtain a usable mesh of quadratic elements. Changing the default angle subtended to 30 degrees will help rectify problems when meshing with quadratic tetrahedral elements.

When meshing multiple volumes it is often convinient to switch the Mesh Lock on to prevent automatic and use the Mesh Now option when meshing is required. The mesh selected geometry option is also useful when trying to refine the mesh in certain areas. The Mesh Now and Mesh Selected Geometry buttons can be placed on the toolbar from the View> Toolbars dialog.

When automatic volume meshing fails the problem may be in either the surface meshing or volume meshing. To establish if the surface meshing has been successful deassign the volume mesh from the model and mesh the surfaces with thin shell elements. Once a successful surface mesh has been attained change the surface mesh type to None and reassign the volume mesh attribute. Since the volume mesh is controlled by the quality of the surface mesh this provides finer control on the quality of the surface mesh.

To increase the success rate of the volume meshing donot specify the element size on the volume mesh attribute. The element size defined on a surface mesh will then be used to control the element size.

Problems arise in meshing if small surfaces or slithers exist as the number of elements generated will become excessive and the meshing algorithm will fail due to invalid element shapes and a lack of memory. Small features and very short lines should be removed prior to creating the volume.

Additional problems will also occur when geometry singularities exists. This often occurs when a line is tangential to an arc as occurs when a cylinder sits on top of a cube whose side length is equal to the diameter of the cylinder.
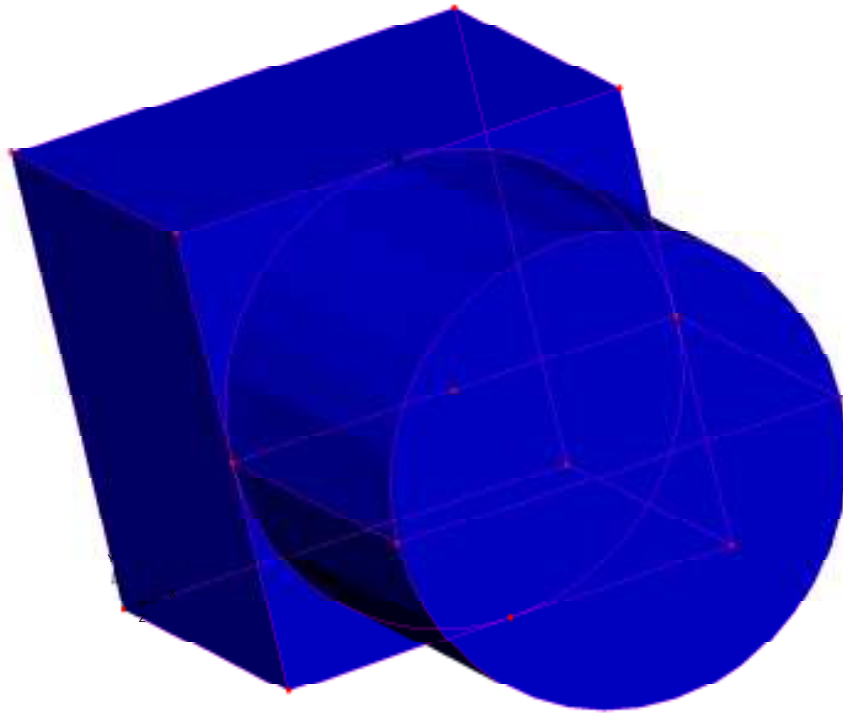
In this case the geometry needs to be adjusted to remove the area where invalid elements would be generated or line mesh attributes need to be defined to force larger elements in the vicinity of the geometry singularity.
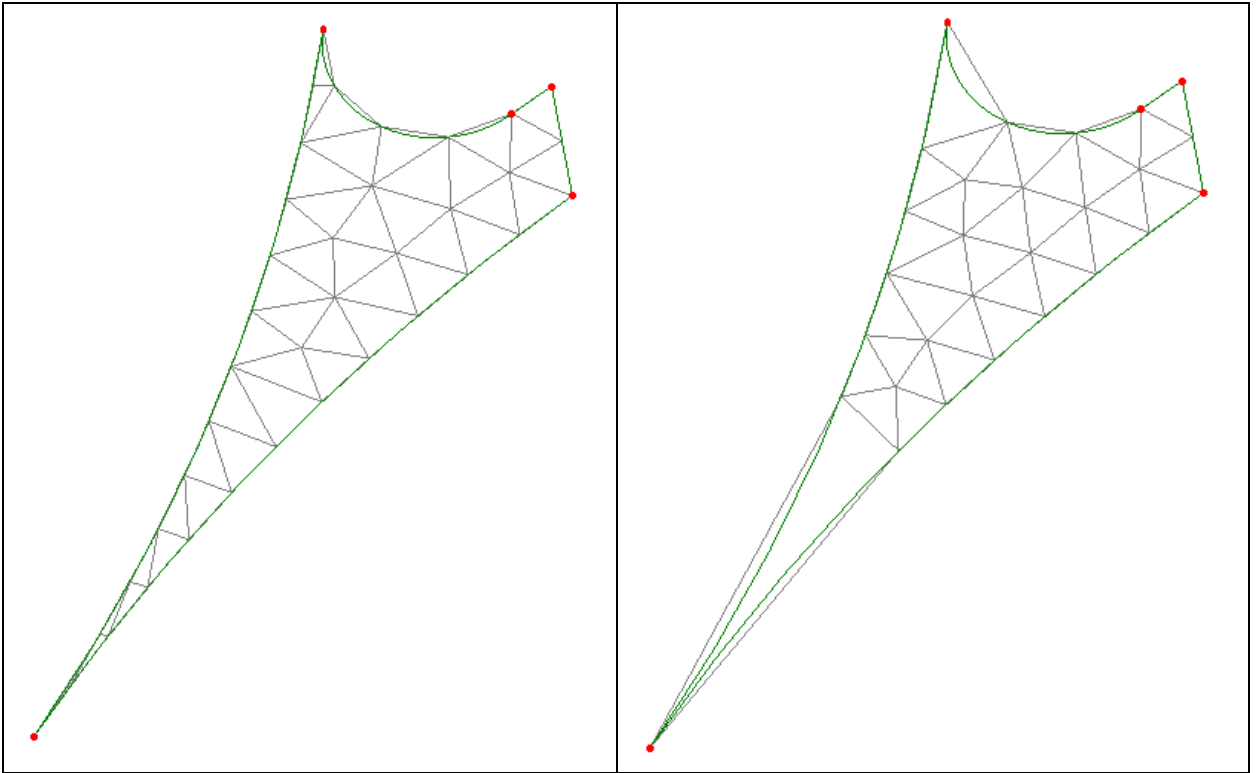
Line mesh assignments used to move elements away from geometgry singularity