CAD model geometry clean up

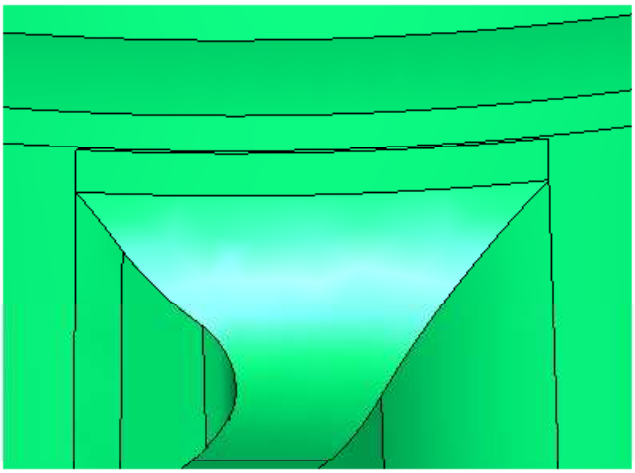
Imported CAD geometry is often unsuitable for finite element meshing without some modification being done. The primary purpose of CAD geometry is for production. Analyst tools should not dictate to the CAD designer how the CAD model is constructed. The analysts tools should be able to "cope" with anything in the CAD model.

Most common in CAD models are "slivers", narrow strip surfaces which physically do not represent anything. They are usually the result of a boolean solid addition in the CAD model where a little amount of penetration was required to join two primitive solids together. These can be legitimately removed and should be removed to avoid poor surface meshing.

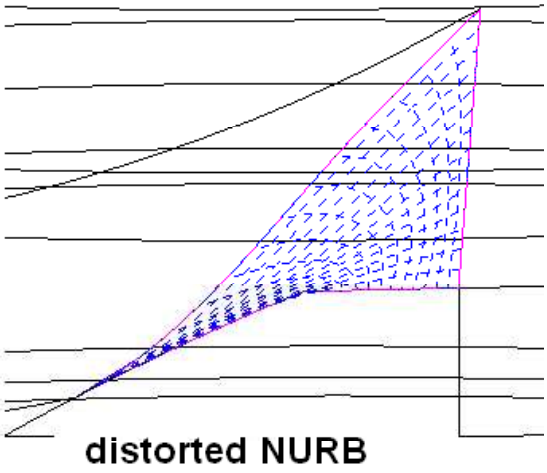
Sometimes the CAD model may contain poorly constructed geometry or even distorted NURB (non-uniform rational B-spline) surfaces. Features like these should be removed and replaced.

Lastly the analyst may wish to decrease the burden on the solver by simplifying the model. Removal of unimportant geometric features of no interest can greatly reduce meshing and analysis times. This task is known as de-featuring.

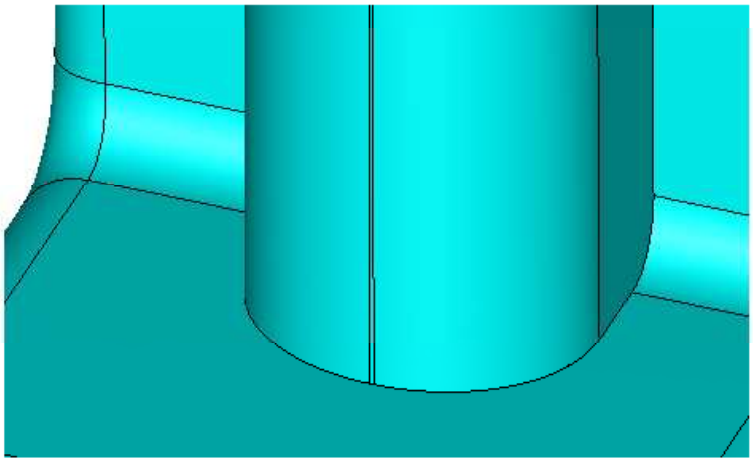
The following tutorial runs through the procedure to perform all of the above tasks in Roshaz.

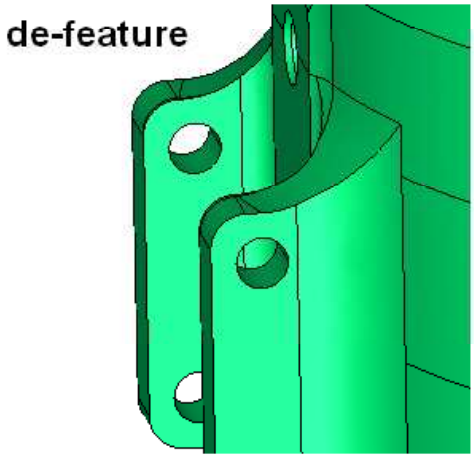


sliver removal



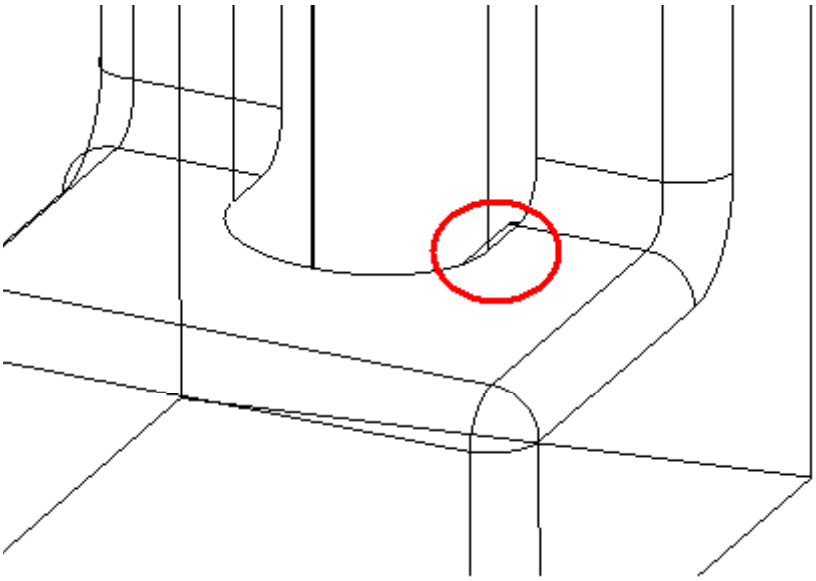
distorted NURB



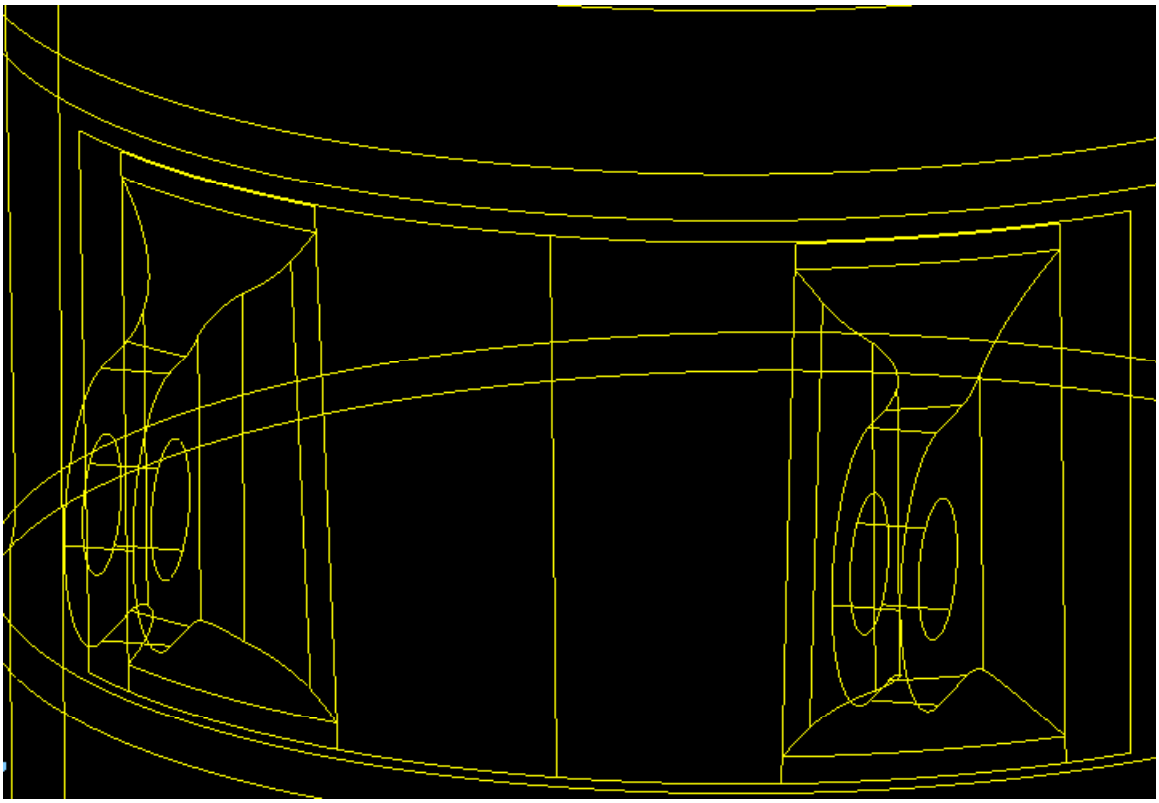


de-feature

Incorrectly defined geometry in CAD model

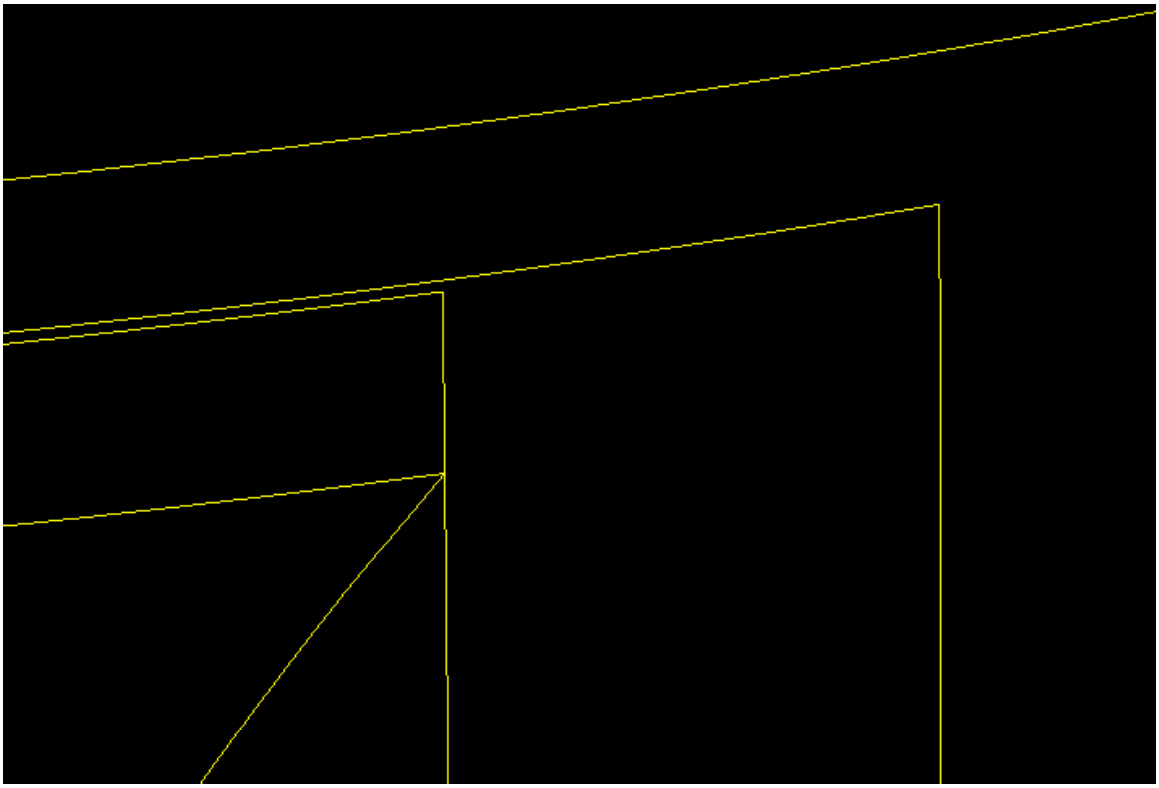


Sliver Removal

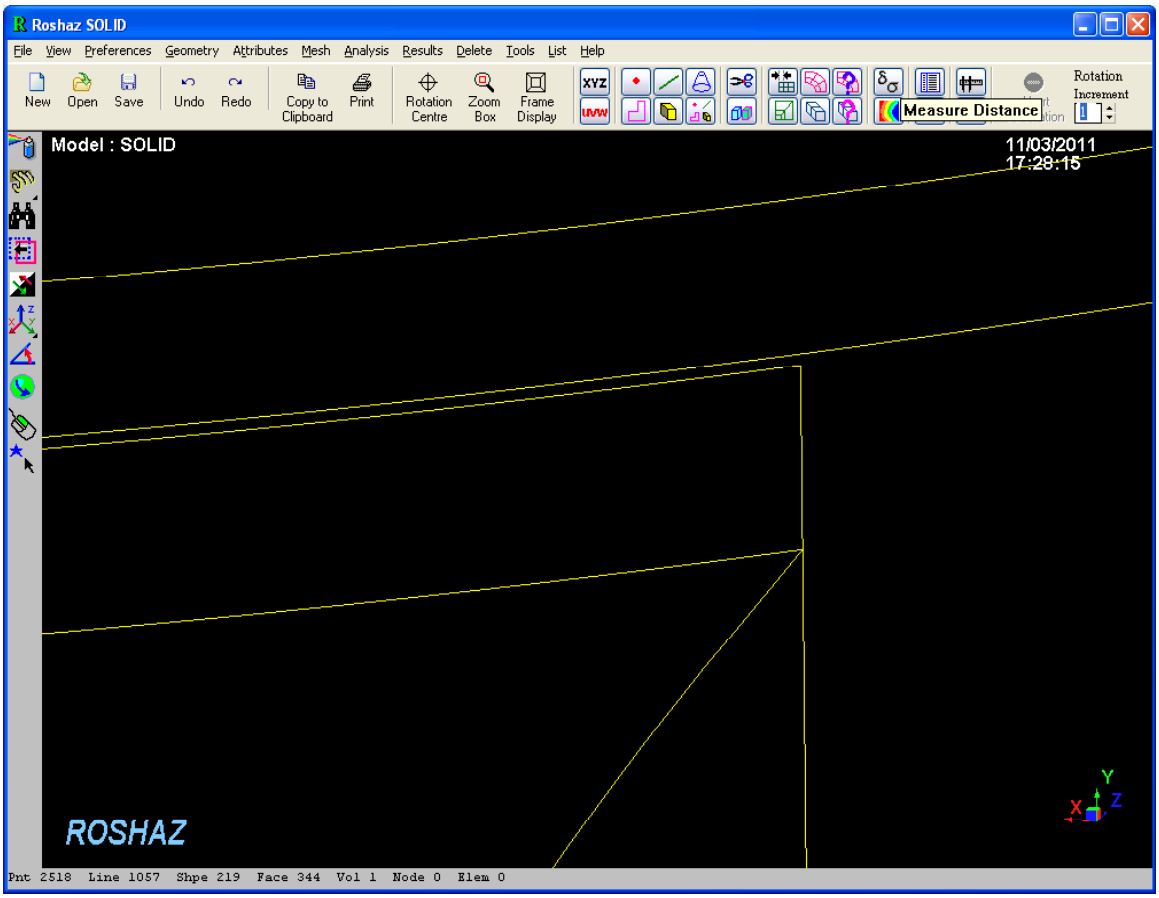


Slivers here are identified by what look likes thickened lines above the lugs.

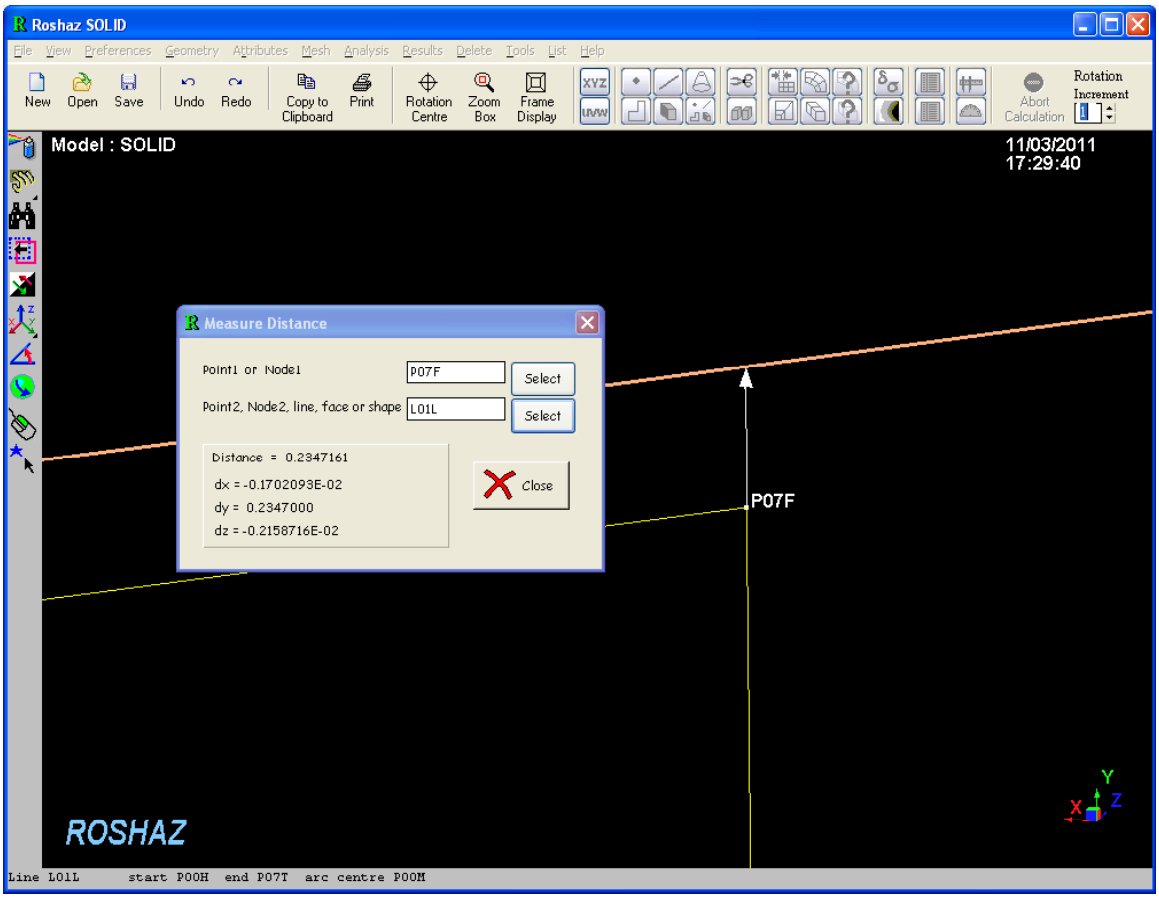
Zooming in reveals the separate lines.



Use the measuring tool (micrometer icon) to find the distance between the two lines.



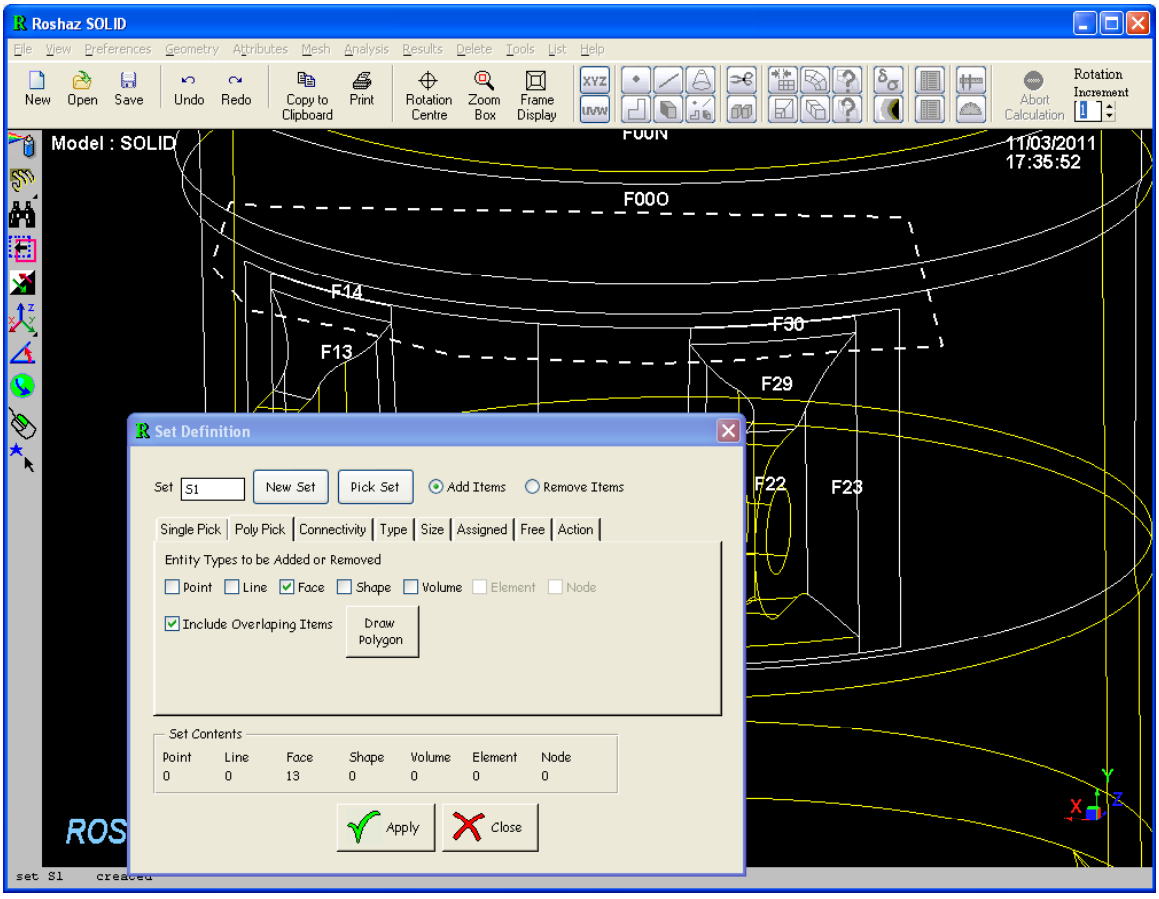
Pick the corner point first then the line above it.



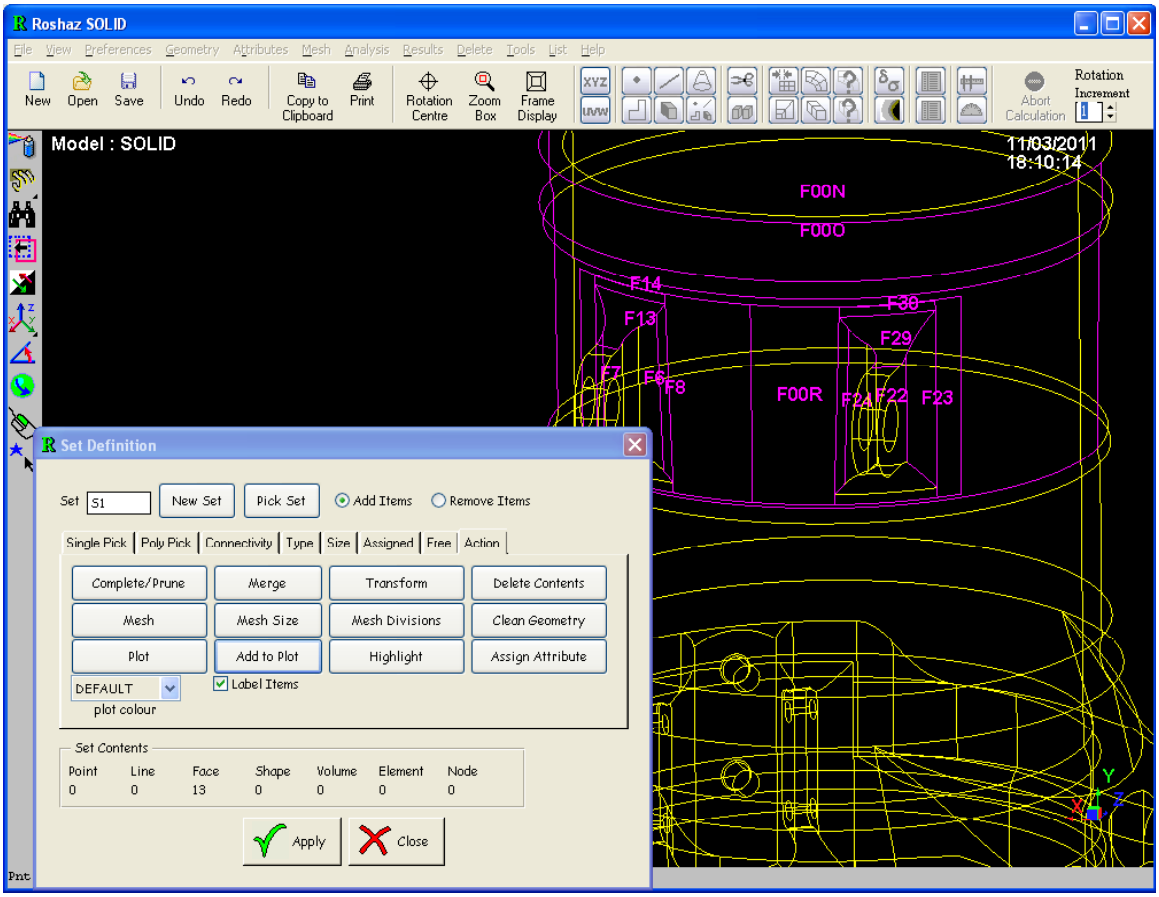
The gap is just below 0.25 This value can be used as a merge or "collapse" tolerance to remove the slither. It is best that this operation is carried out locally and not applied to the whole model. Therefore it is first necessary to create a set of faces comprising of the faces adjacent to the slither.

Click on the create/edit set icon.

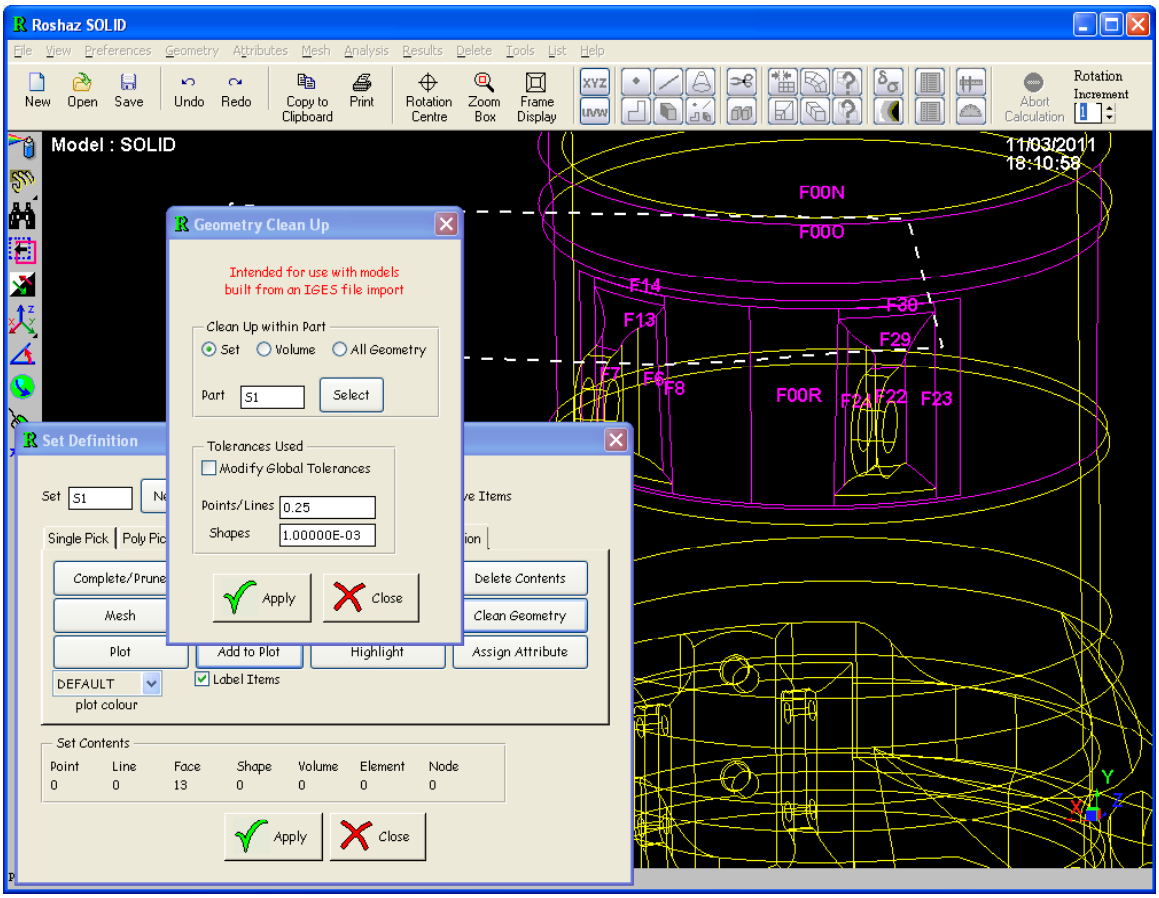
Use the poly pick facility, check faces and include overlapping items, then draw a polygon around the slithers and click apply



Click the Action tab and click the add to plot button, the faces in the set are then displayed.

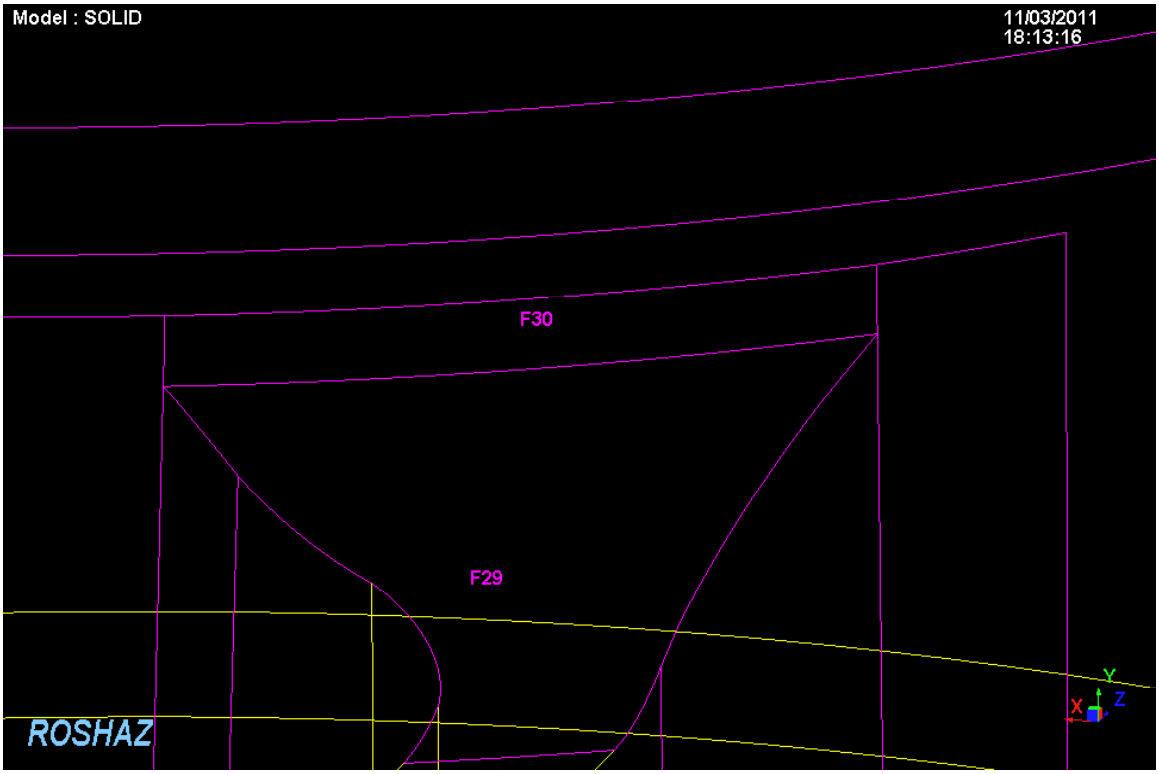


Now click the clean geometry button



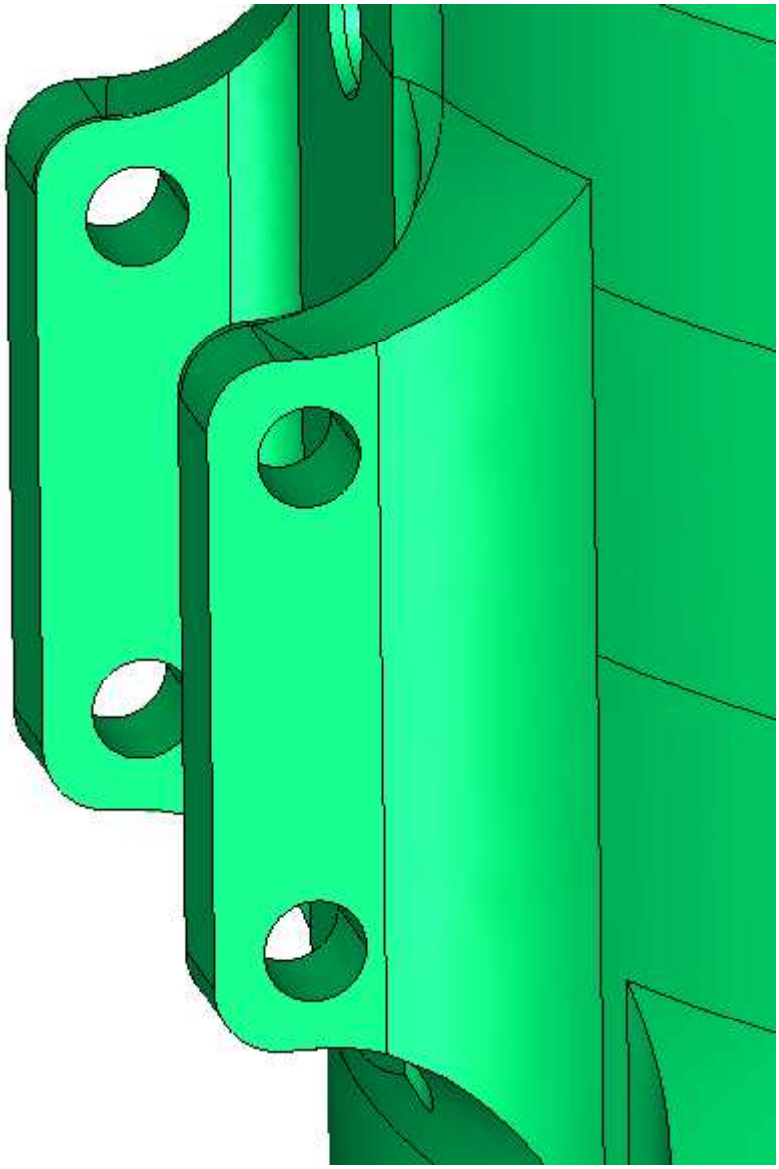
In the clean up dialog set the tolerance value for points/lines to 0.25 and click apply. Close both dialogs.

Zooming in shows that the slivers have been removed.



De-Featuring

Some features can be removed very easily, whilst others take a little more effort and some repair work after the features have been removed is necessary.



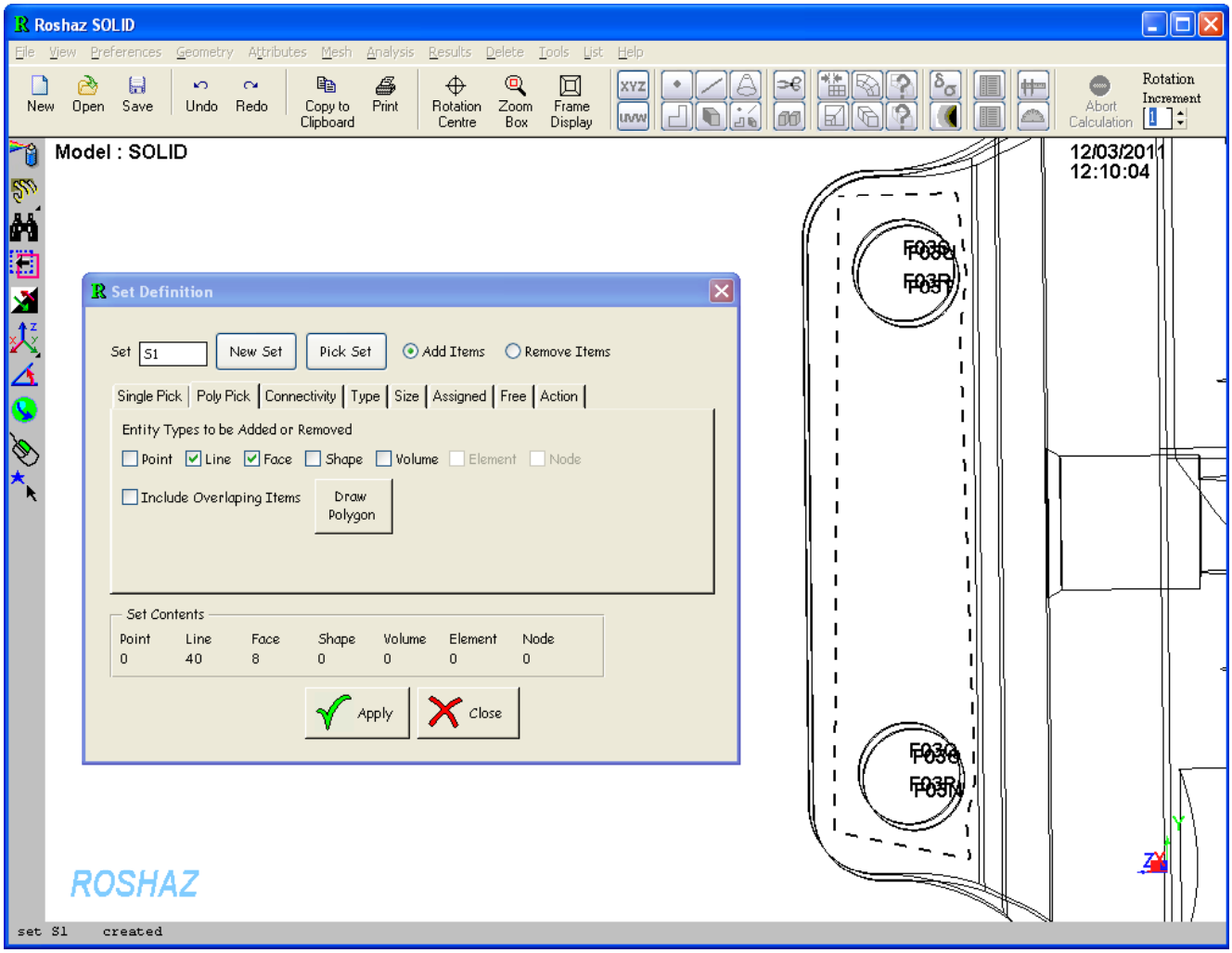
The bolt holes through these flanges are not important to an analysis and can be safely removed to reduce model size.

The bolt holes do not interfere or intersect any other geometry features and hence their removal is very straightforward.

This is accomplished by deleting the faces of the hole bore PLUS the boundary lines of the bore faces as well.

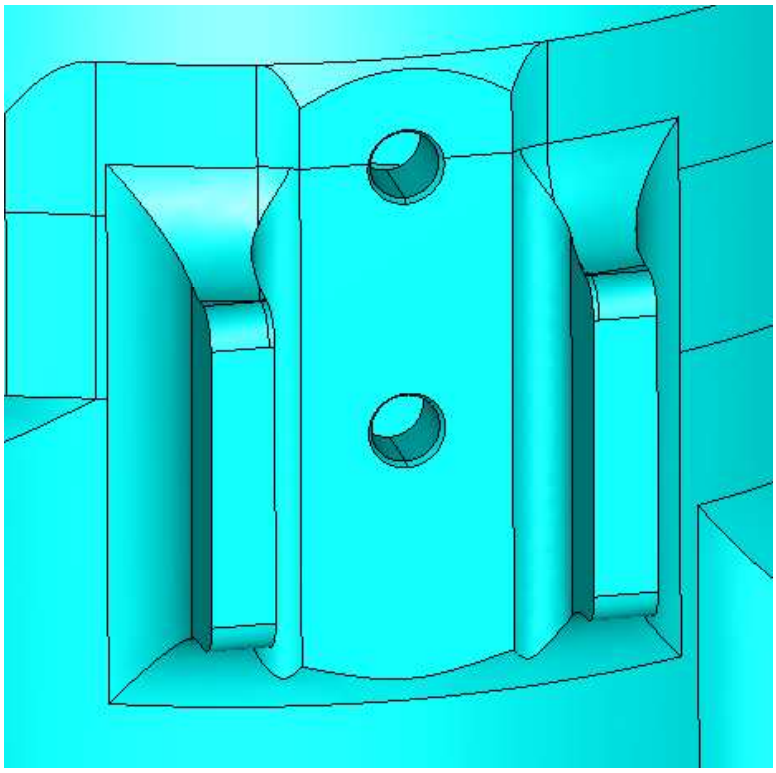
It is important that the bore boundary lines are also deleted because they are shared with the side faces of the flanges. The side faces remain minus the hole boundaries.

Click on the create/edit set icon, rotate the image to be in line with the bore holes (as seen below). Select the poly pick tab in the dialog and check the line and face boxes, then draw a polygon around both pairs of bolt bore holes and click apply.



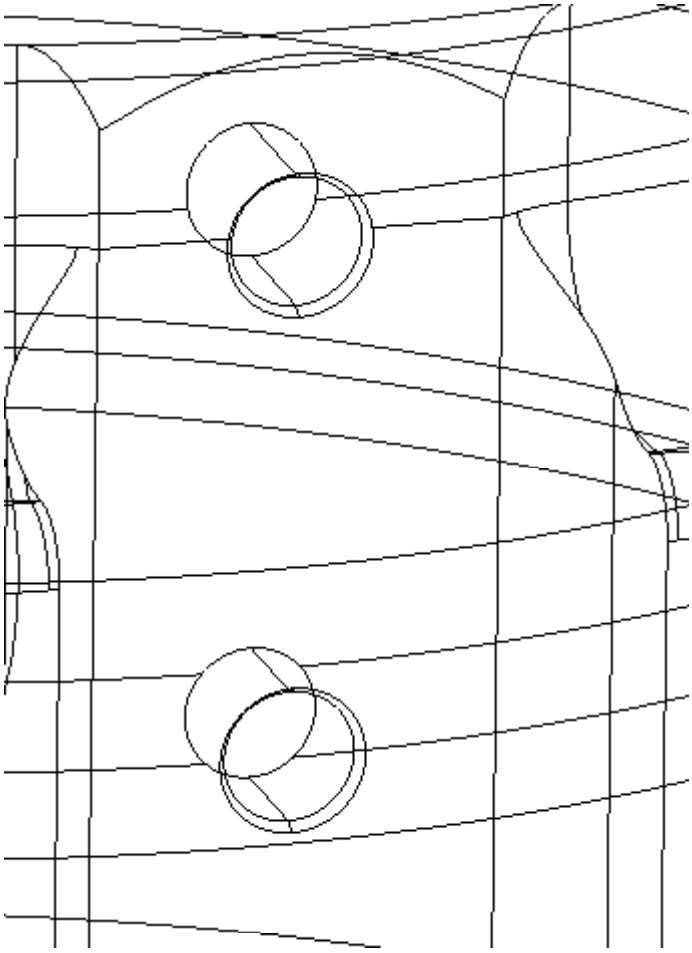
Select the action tab in the dialog and click on the delete contents button. Close the dialog and repaint the image (with the spray can icon). The bore holes have been removed. Under the main menu tools select check geometry and the text console window should report zero errors.

Although the bolt holes have been successfully removed by deleting the face and boundary lines used in their definitions the point and shape entities used by theses lines and faces remain within the model database. To delete these superfluous points and shapes under the tools menu select prune geometry. This command works on the entire model. In a 3D model containing volumes the entities will be pruned back to include only those used in the definition of the volumes. Thus any faces which are not part of a volume definition are deleted and the same applies for points, lines and shapes. In a model just containing faces as the highest entity, then any points, lines or shapes not used as part of a face definition are deleted by the prune command.



De-featuring of the holes through the main barrel between the flanges is more involved.

A wire-frame plot reveals more information than a shaded image.

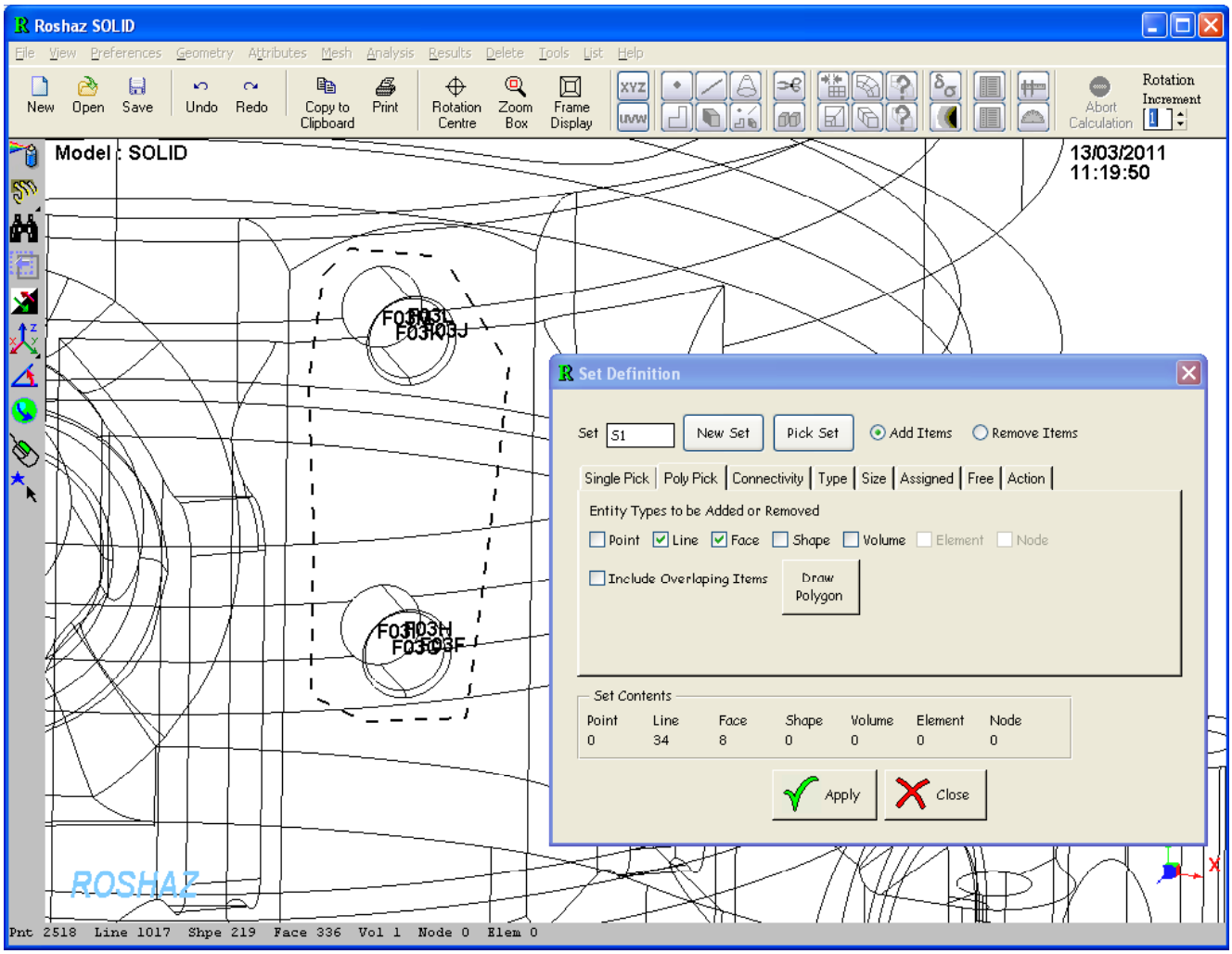


Several face boundaries on the inside and outside of the main barrel are intersected by the holes.

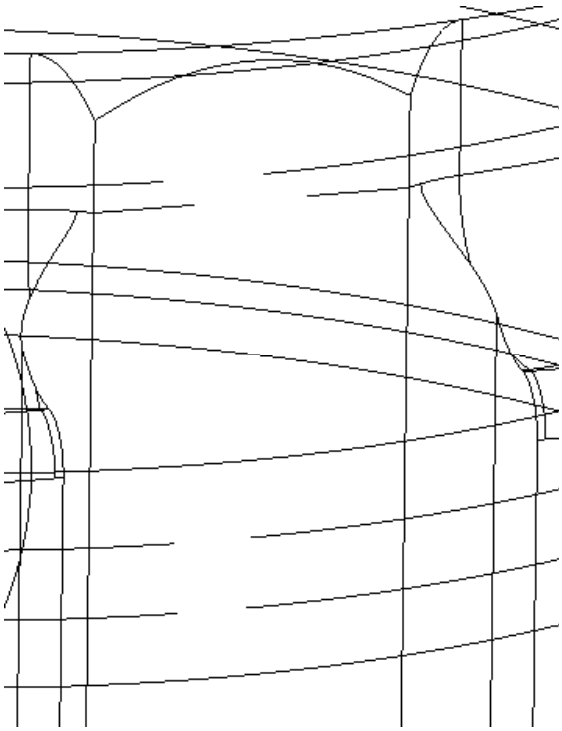
Simply deleting the geometry of the holes will leave discontinuous boundaries on the remaining adjacent faces.

Therefore some "repair" work is required on these faces subsequent to the hole removal.

Create a set consisting of the lines and faces of the holes.



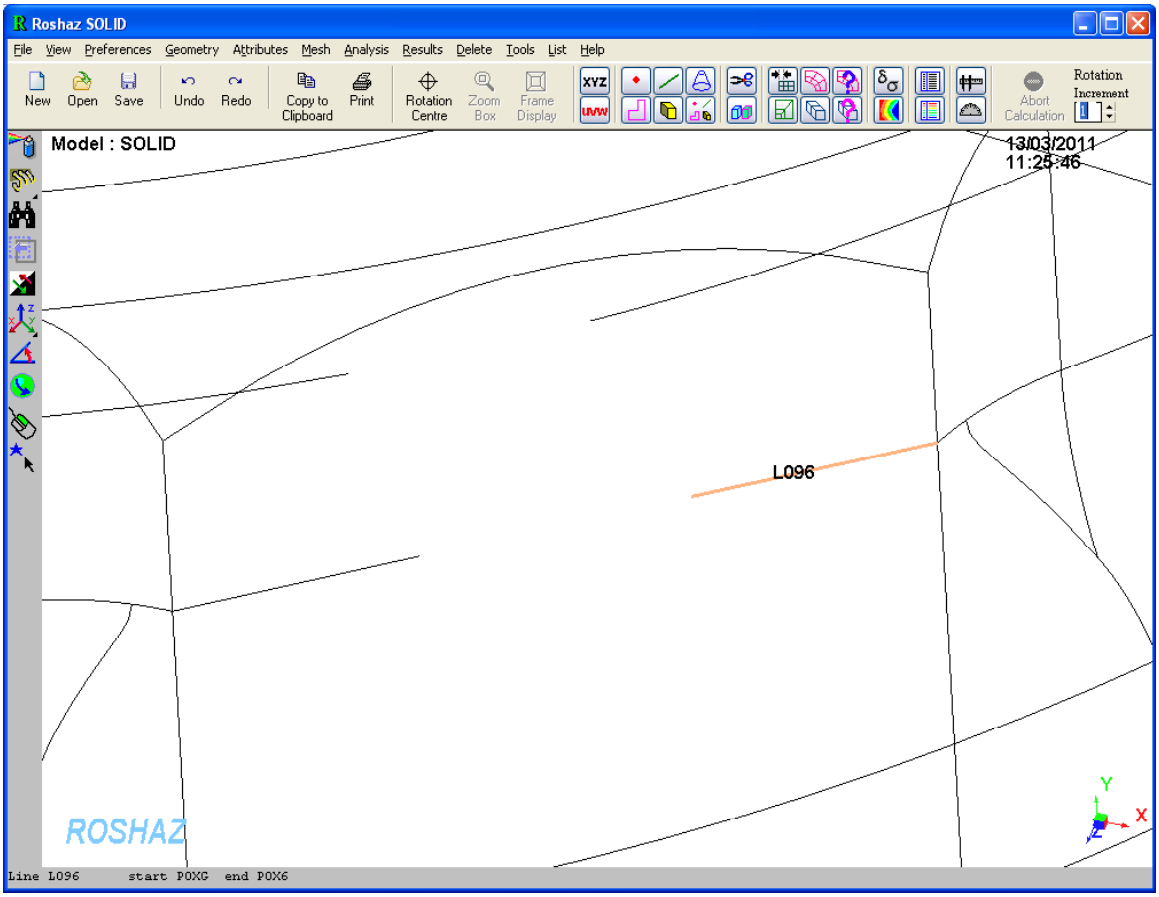
Select the action tab sheet and click the delete contents button, close the dialog box and then repaint the picture.



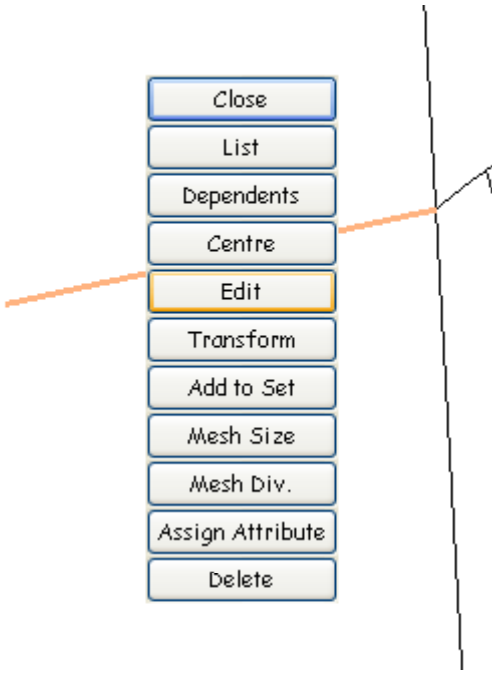
The breaks in the wire-frame boundary lines are clear.

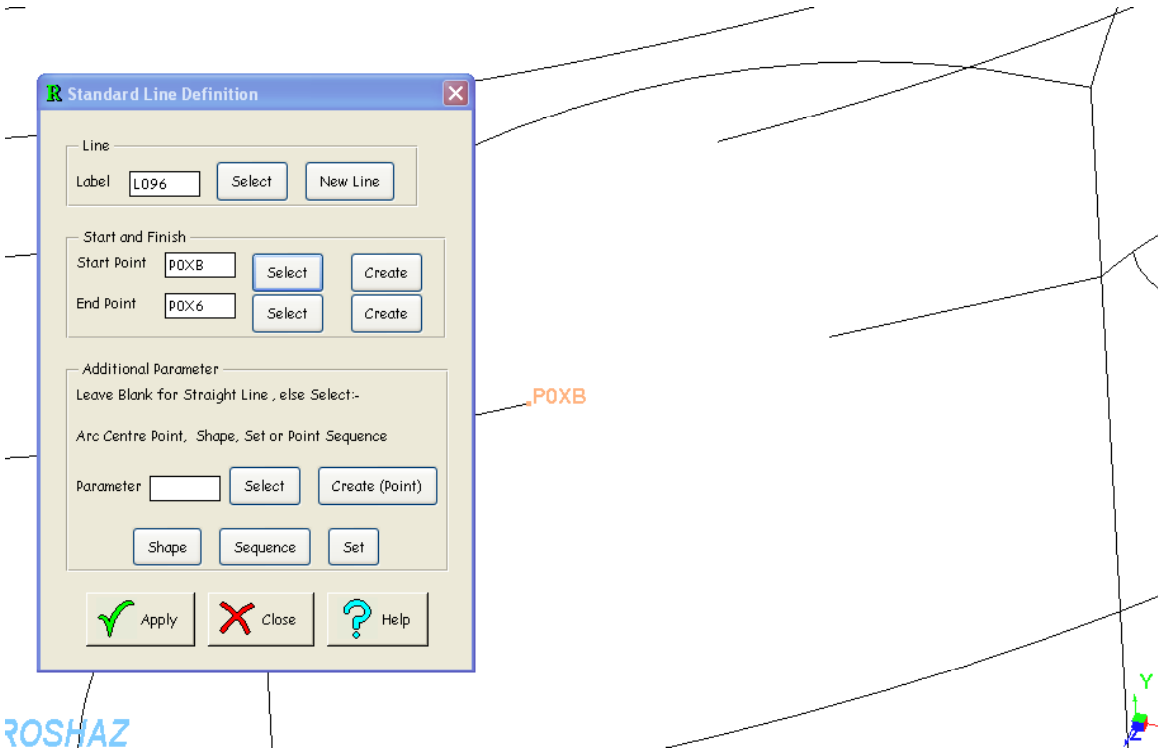
The solution is simple, extend the existing lines by re-definition of their start or end points.

Zoom in on one of the broken boundaries, hover the mouse over one of the lines until it gets highlighted, the line label commences at a position one third along the line length from the start point. This tells you which is the start and end point of the line. Also below the graphics window the text bar lists the line's start and end point labels.

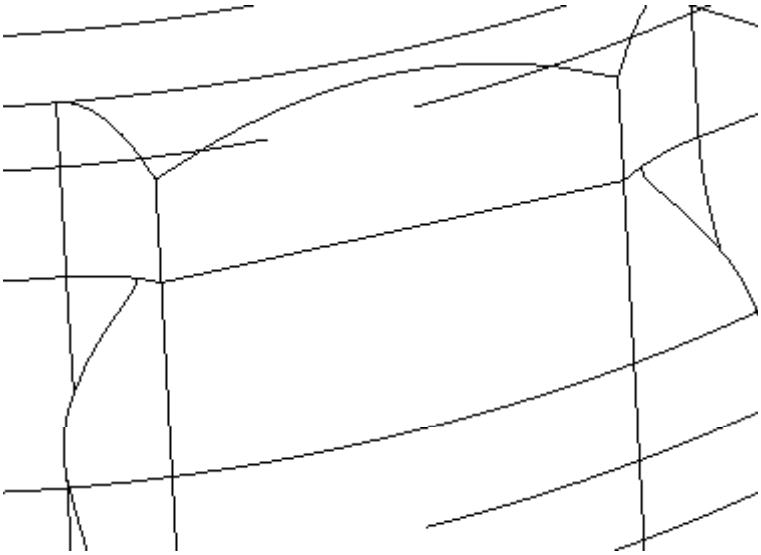


With the line highlighted right click on the mouse and select edit from the pop up menu



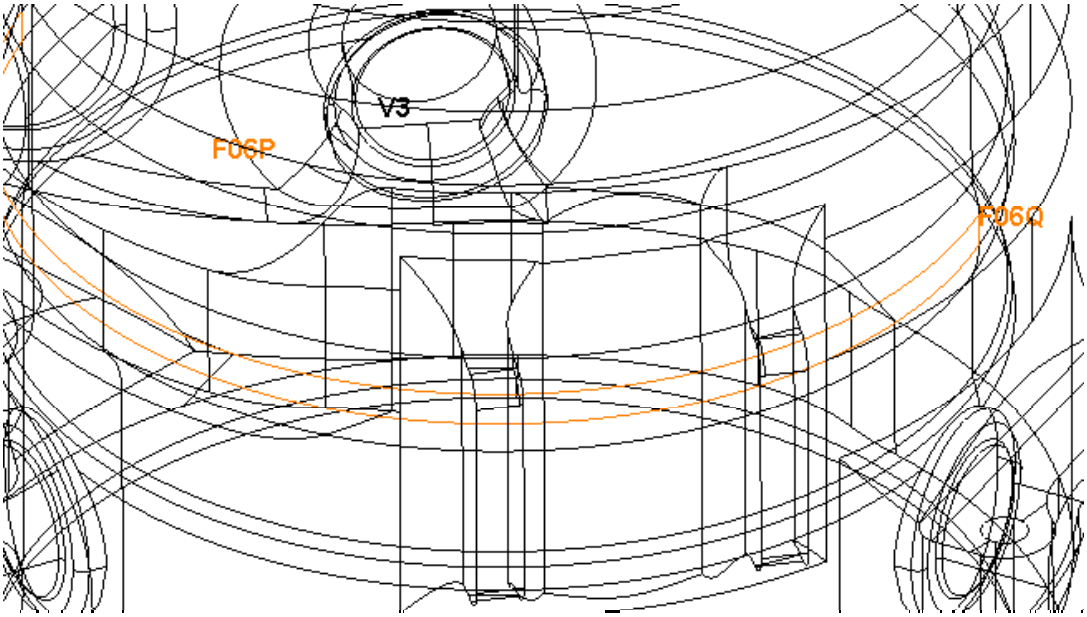


Select the start point for the line to be the point on the other side of the gap and click apply. Repaint the picture.

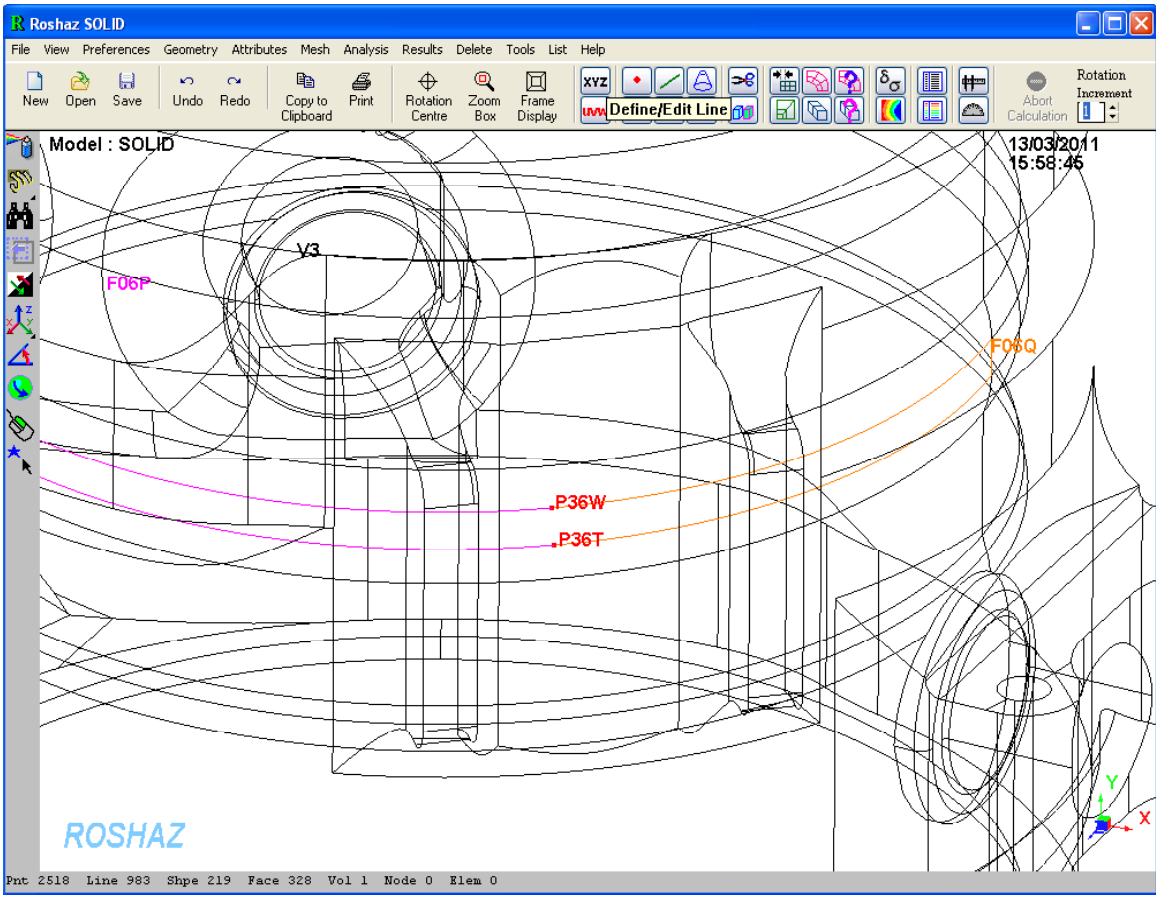


The break or gap in the face boundary has been closed. This one particular problem has been fixed.

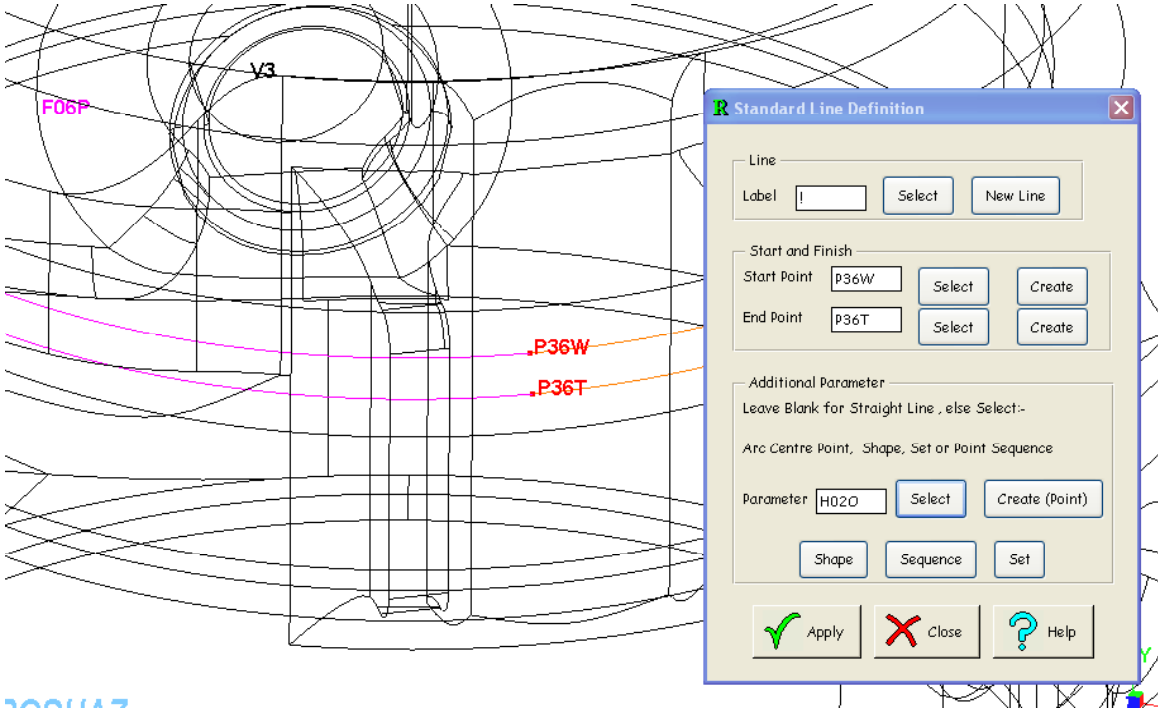
Repeat the procedure to fix all the line breaks. Repaint the picture and under the tools menu select check geometry. The geometry check reveals a problem, this is detailed in the console text window. Two faces are reported as being discontinuous. They are highlighted graphically and the bad faces are placed in a set which is also reported in the text console window.



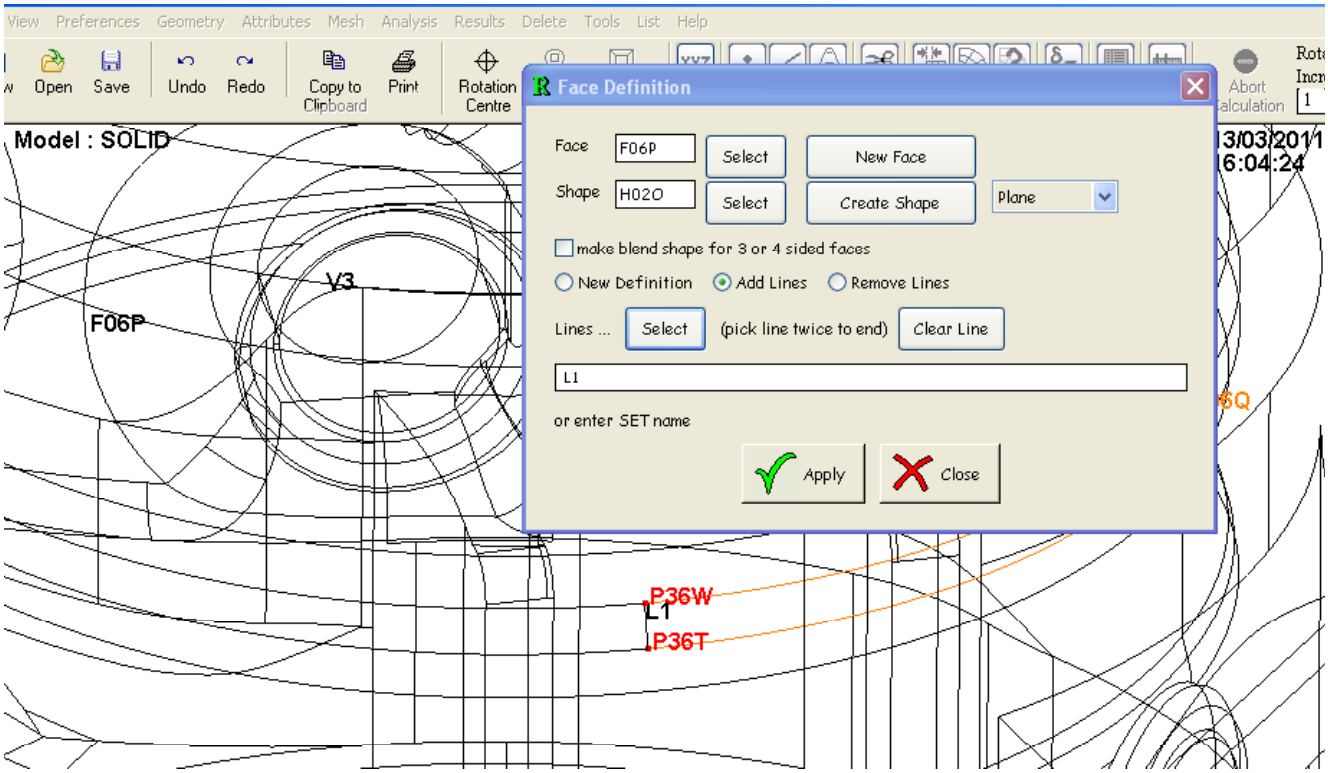
The reason for the problem is that the hole before it was removed provided boundary lines to the two faces on either of its sides. These boundary lines had to be removed. The problem is fixed by creating a replacement boundary line which is then shared by both of the bad faces. Add points at line ends for one of these faces and click on the define/edit line icon.



Select the start and end points for the new line on either side of the break in the face line loop. For the third parameter highlight and click on the label of one of the bad faces, this then selects the embedding shape of the face. Then click apply and close the dialog.



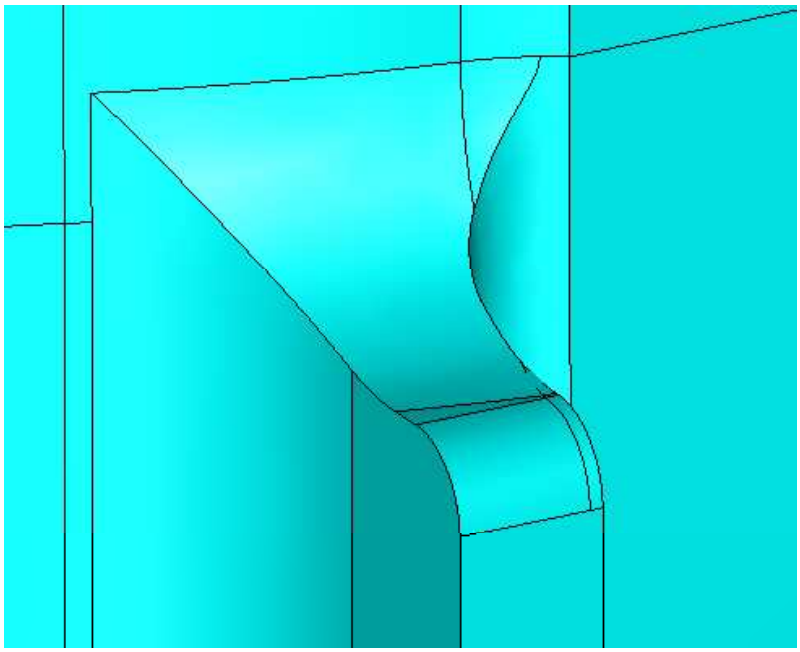
Highlight one of the bad faces with the cursor hover over, right click and select edit from the pop up menu. Select the add lines radio button then the select the line that was just created above and click apply.



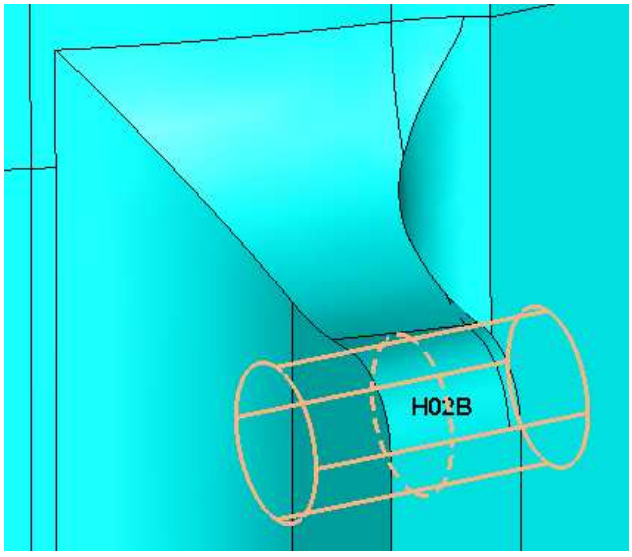
Leave the dialog open, select the other bad face and repeat the procedure. Both faces will now be fixed. Repeat the tools check geometry command, no errors should be reported.

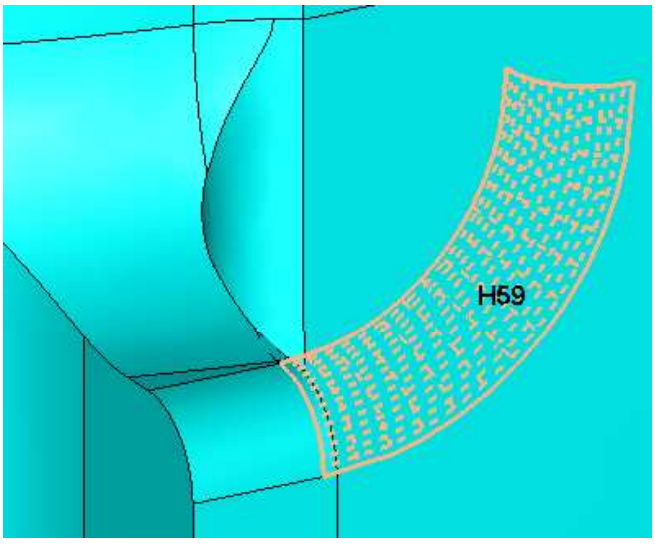
Model Simplification

The corner fillet on these flanges show a number of small faces are present. Each face is meshed separately thus these small faces may generate poor quality elements with high aspect ratios, unless a very fine mesh size is used. It is self evident that this patch work of faces serves no real purpose and can be simplified without harming the integrity of the model.



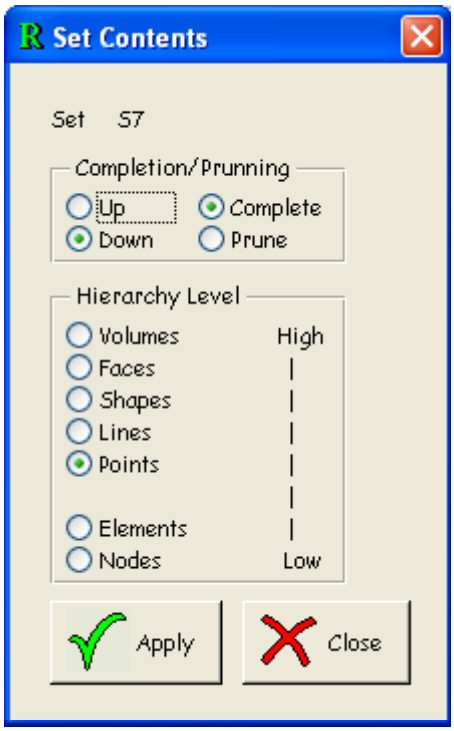
The concatenate (join) faces command under the tools menu does not join any of them together because they have different embedding shapes in their definitions.



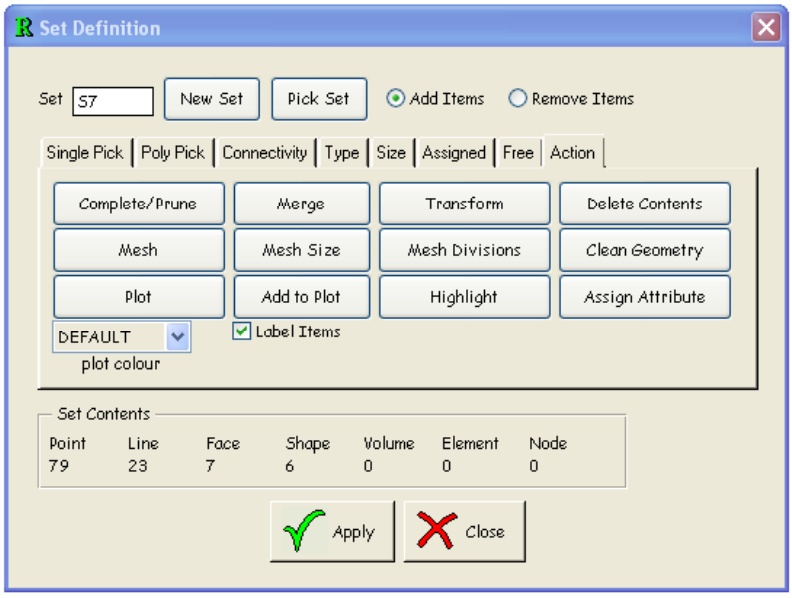


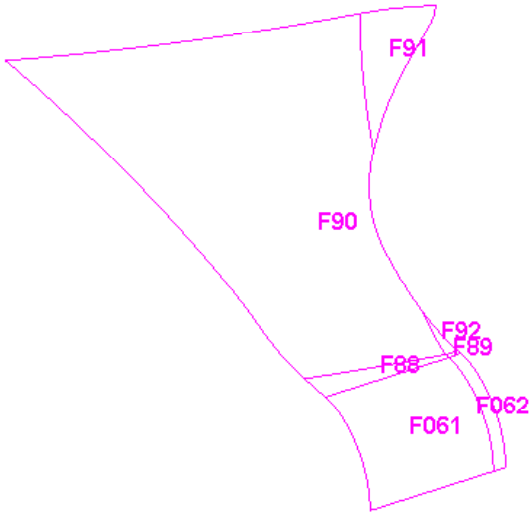
Most of the fillet uses a simple cylinder shape whilst the little section at one end has a toroidal type shape.

Create a set of these faces, under the action tab click plot and click the complete/prune button.



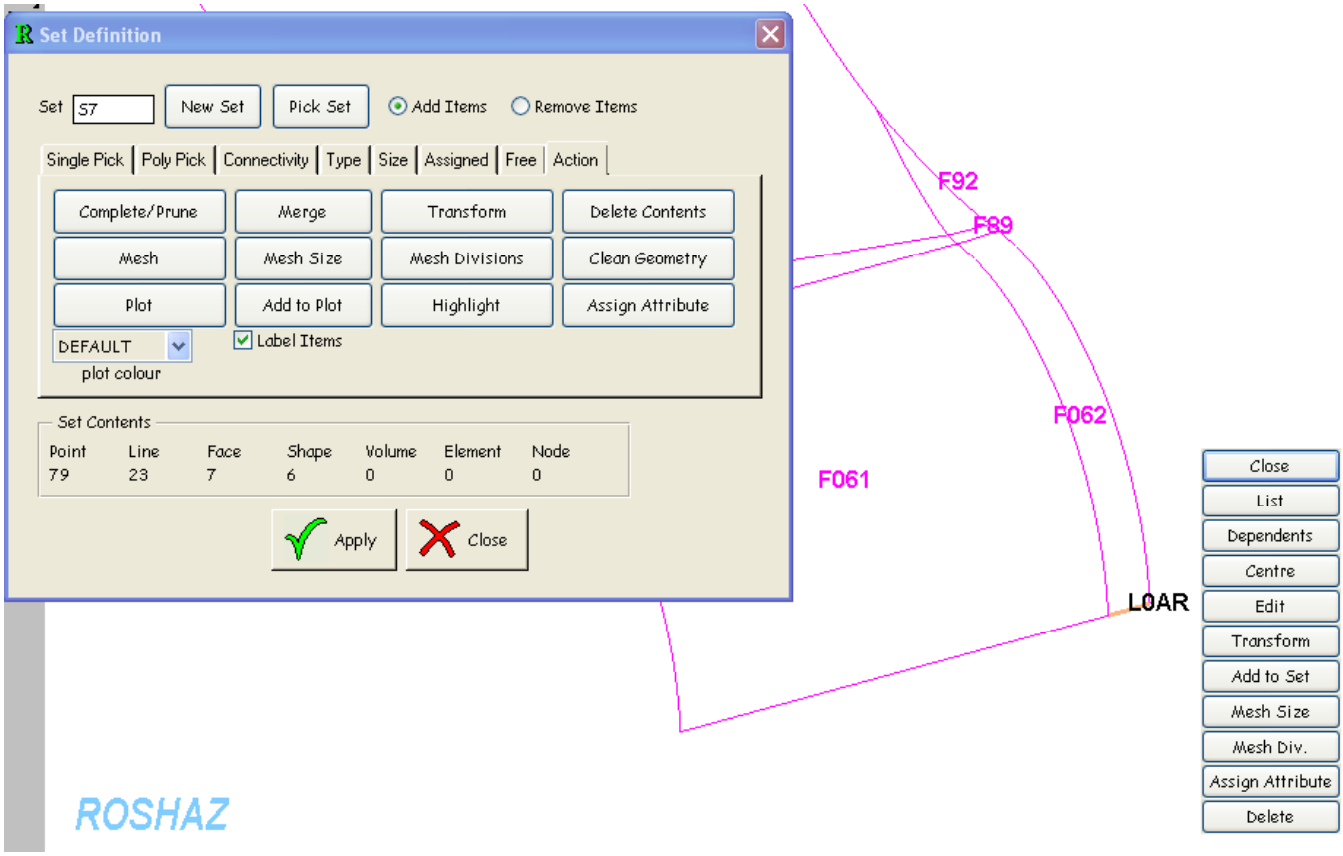
complete the set downwards to include points, lines and shapes used in the face definitions.



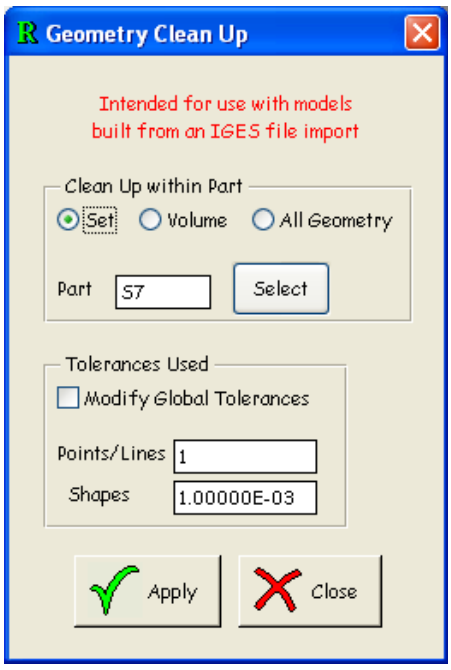


Hover the mouse over the short line as shown below, right mouse click and select list from the pop up menu. The console text window then reports the line length as 0.889

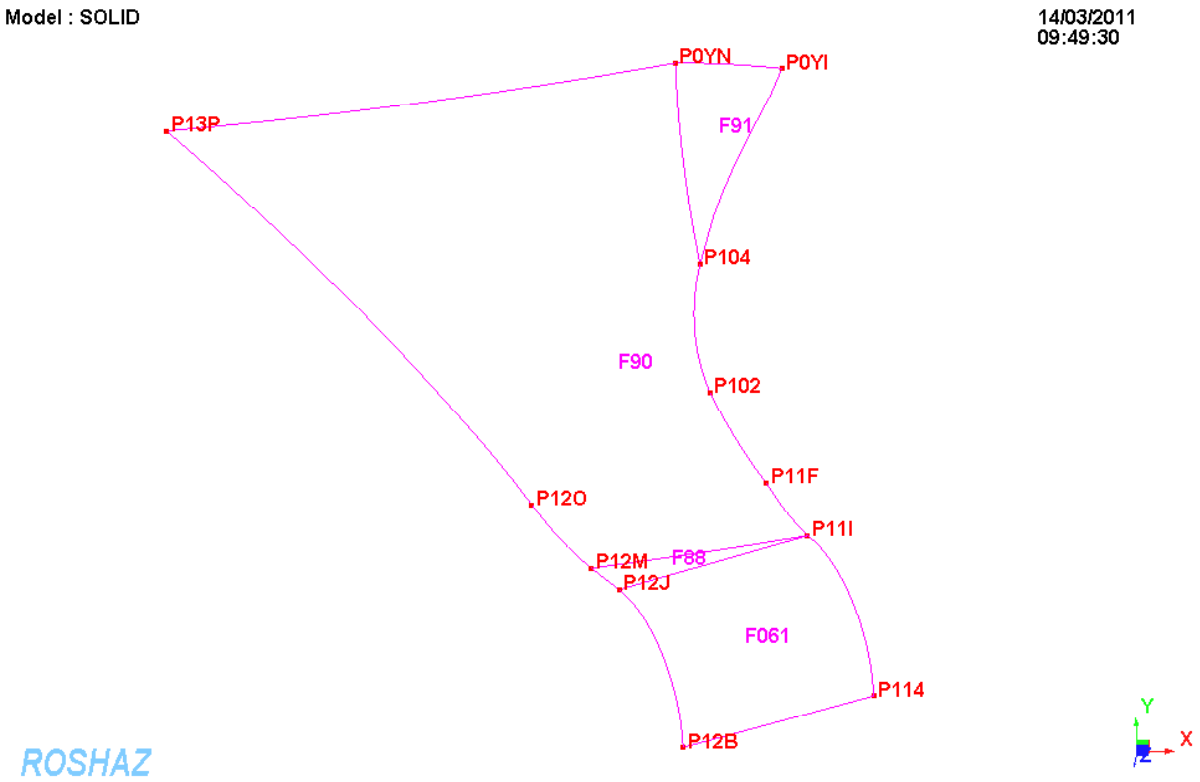
Thus a merge tolerance value greater than 0.889 can be used to collapse the small faces F92, F89 an F062 as seen below.



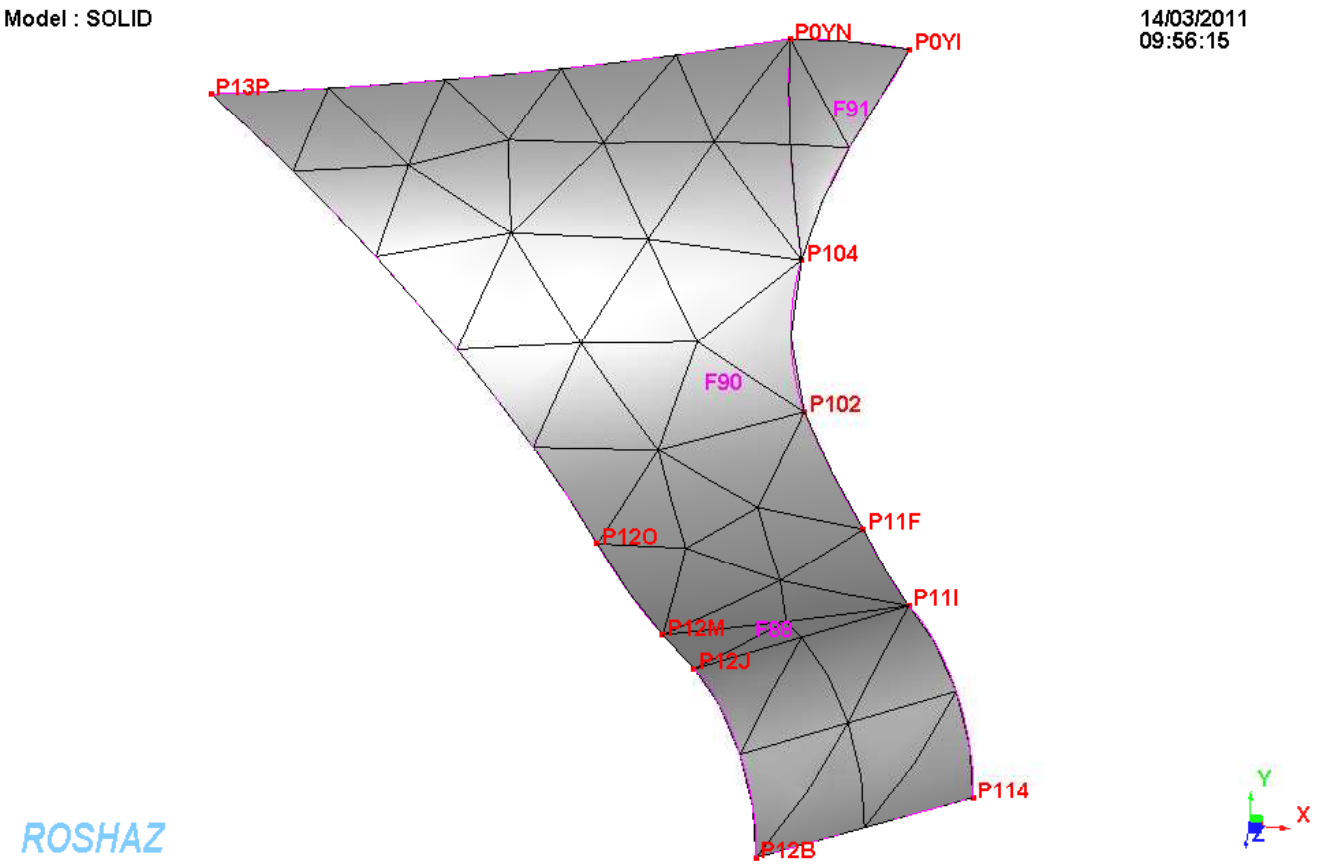
Click on the clean geometry button, set the points/lines tolerance to 1 in the clean up dialog and click apply.



Repaint the picture, add point line ends to the plot. This shows that all small length lines have been removed

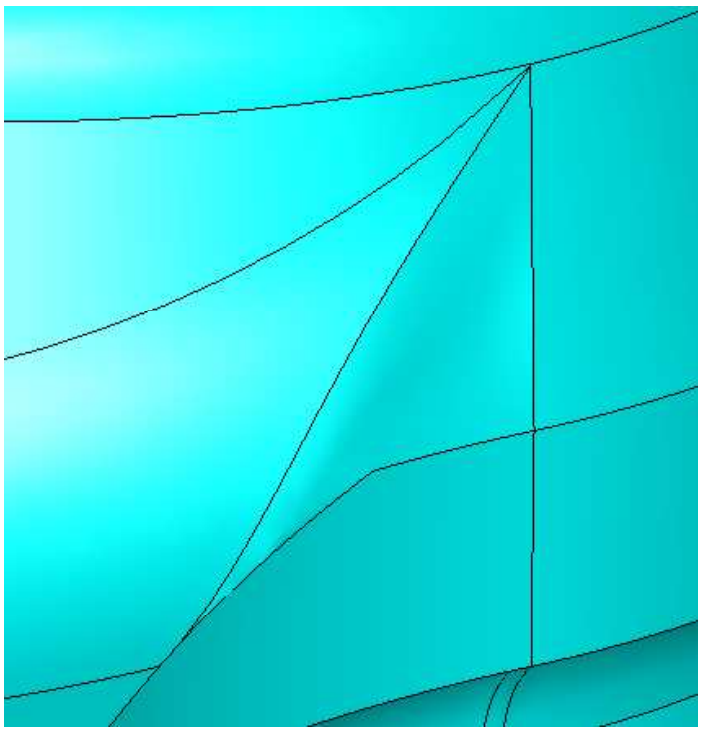


Using the mesh size button to set local mesh size in the set to 5 and clicking the mesh button yields the following quality mesh which has not been hampered by short boundary lines.

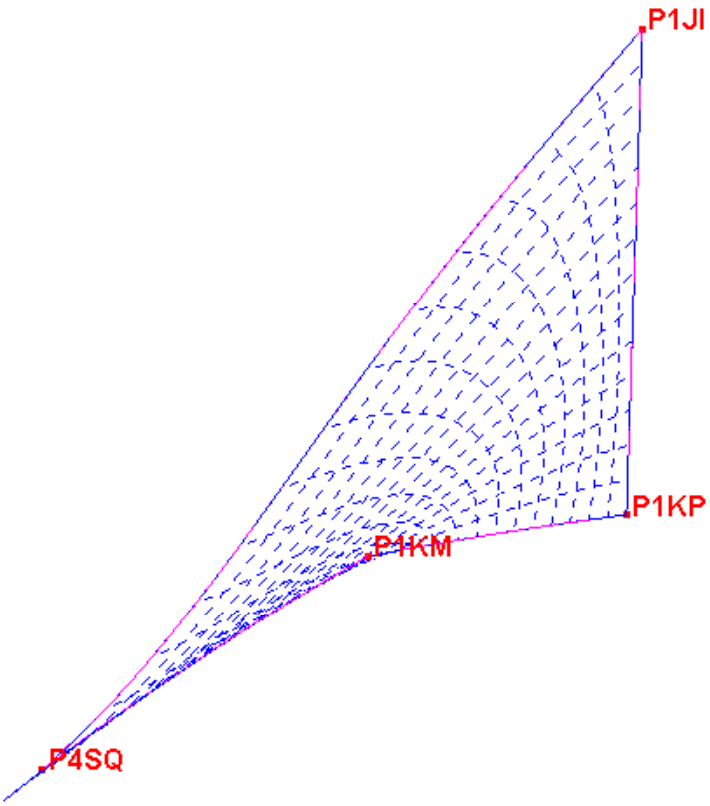


Geometry Modification - NURB replacement

The face in the centre of the picture below lies on a very distorted NURB shape. This will cause the meshing tools to create distorted elements. The distorted NURB shape has to be replaced.

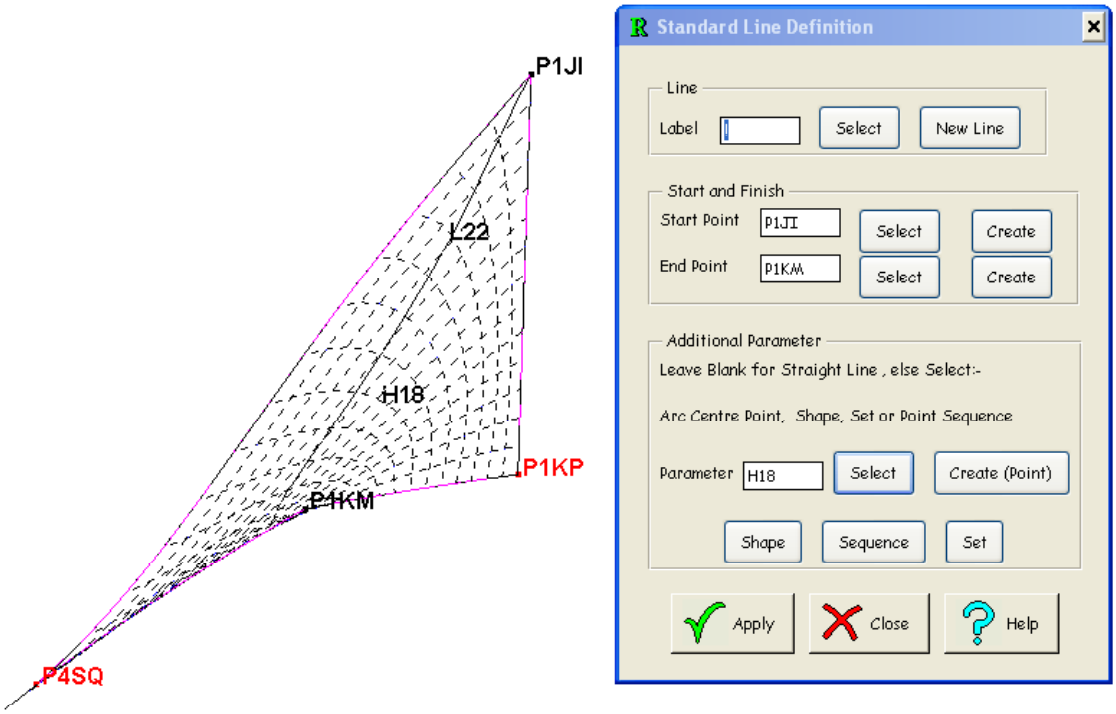


The face is four sided with one internal angle greater than 180 degrees where the NURB shape is very distorted as seen in the following plot showing the u,v isolines of the shape.

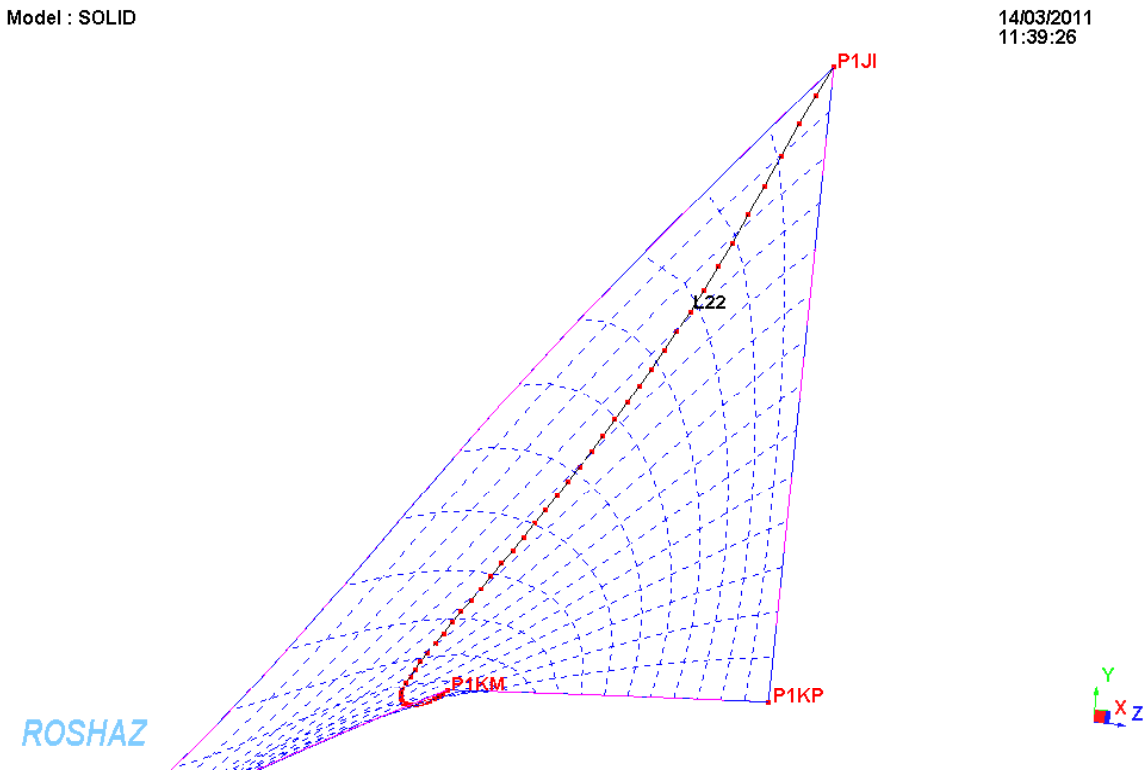


Click on the create/edit line icon

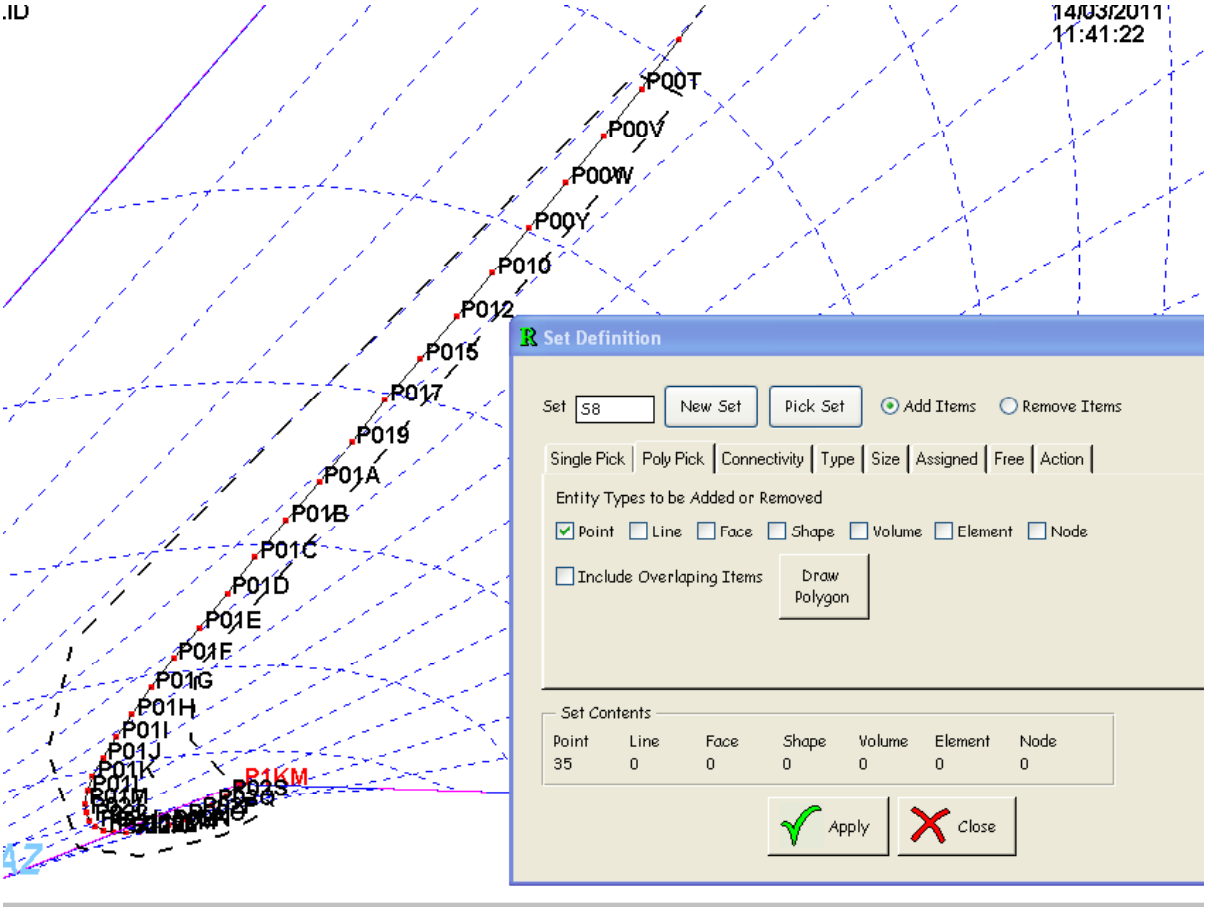
Create a line as shown below, across the face, using the NURB shape as the third parameter.



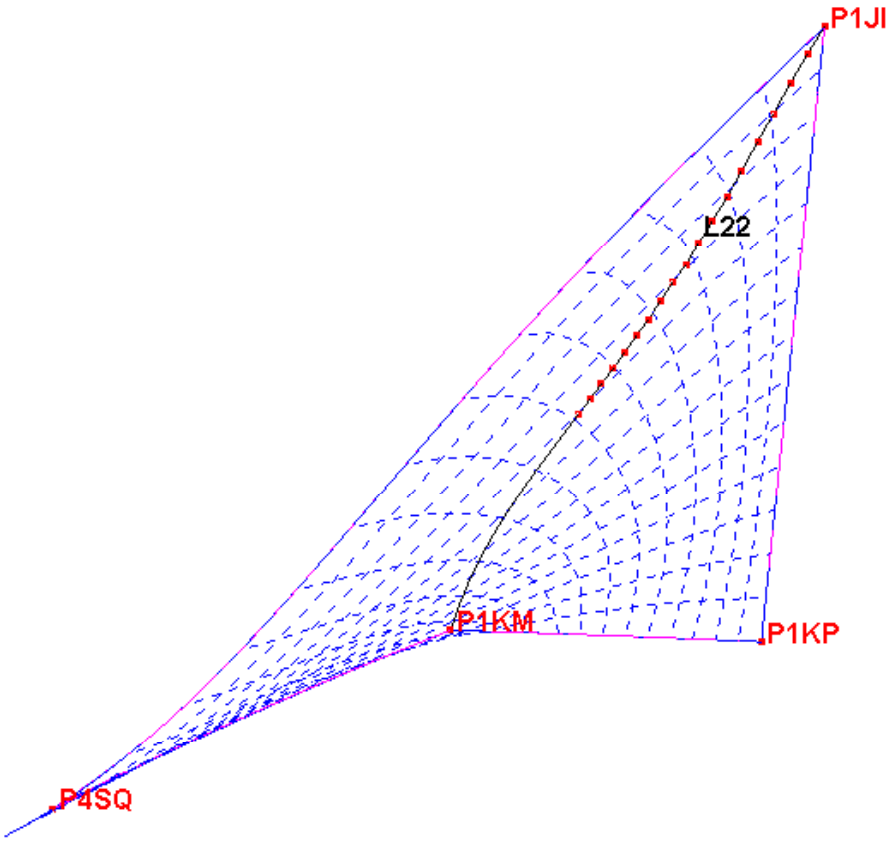
The line follows the surface of the face between the two end points, but has trouble where the NURB is very distorted. Add the line to the picture, also add points on the line to the picture.



Zoom in on the distorted end of the this new line and create a set of the track points at this end , BUT do NOT include the line end point in the set.

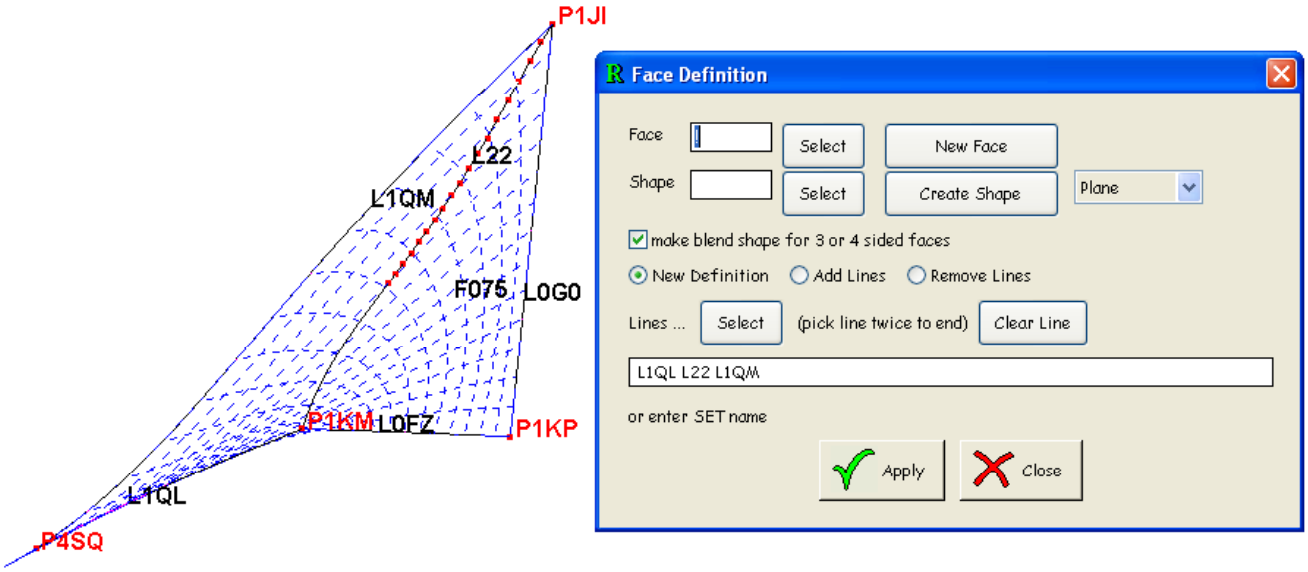


Go to the action tab sheet and click delete contents. Close the set dialog. Repaint the picture.



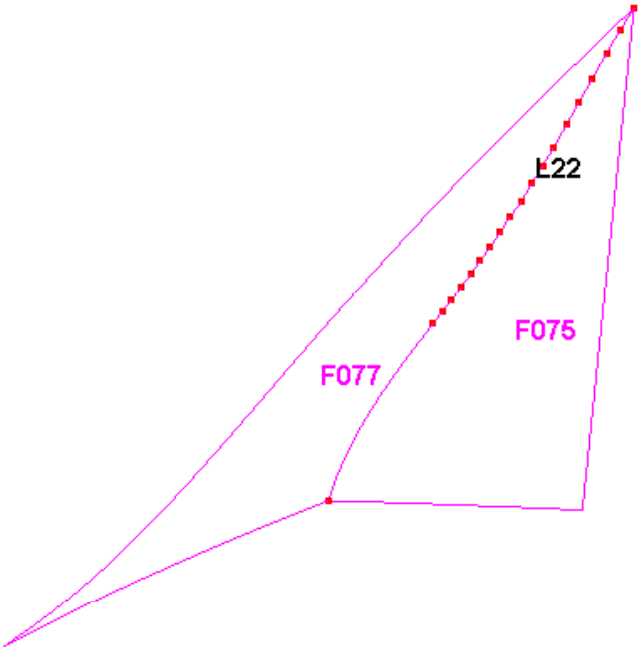
Click on the create/edit face icon

Create two three sided faces using the new line in both definitions. Ensure that the box for make blend shape is checked



OSHAZ

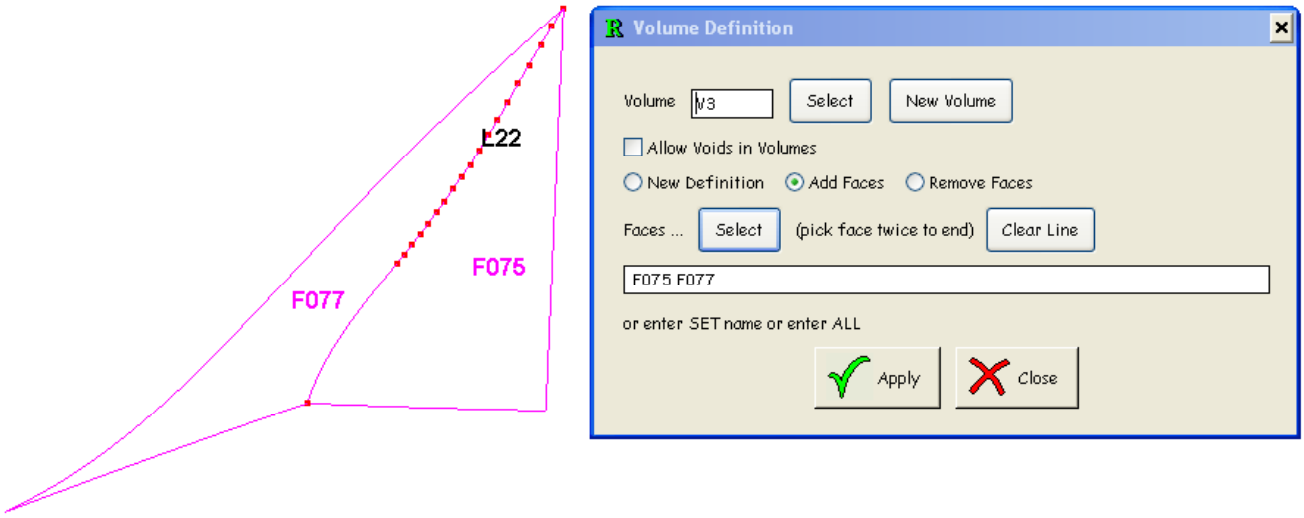
Delete the original face with the distorted NURB shape. Add the two new faces to the picture.



Finally click on the define/edit volume icon

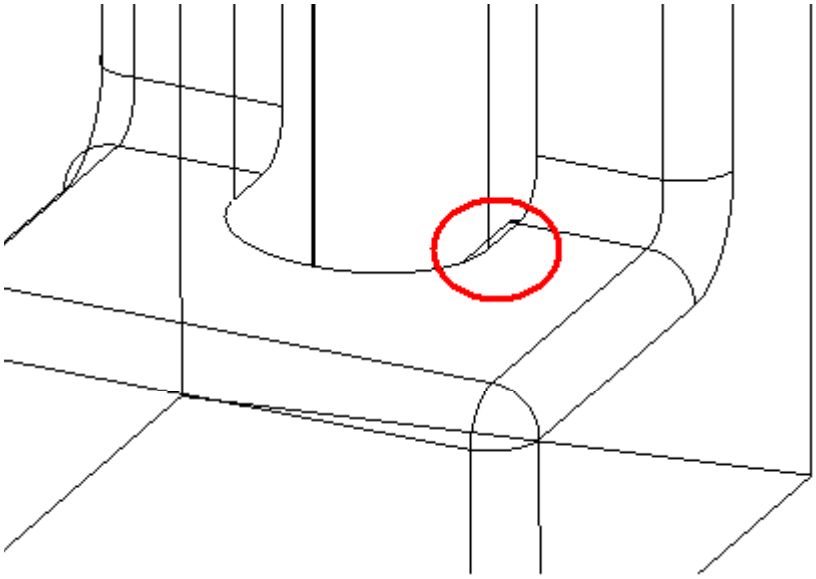
Select the volume that the now deleted face belonged to, check the add faces radio button and select the two new faces and apply. This fills the hole in the volume caused by the deletion of the original face.

Check the model with the tools --> check geometry command.



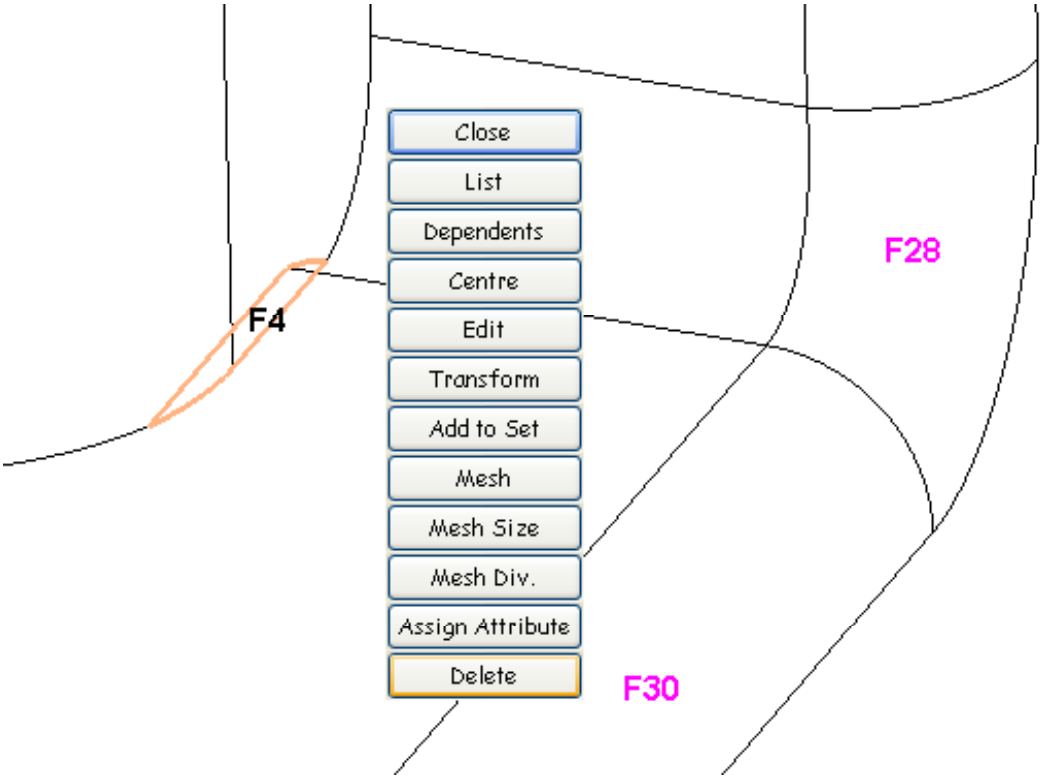
Geometry Modification - Edit Geometry

Repair of badly constructed CAD geometry

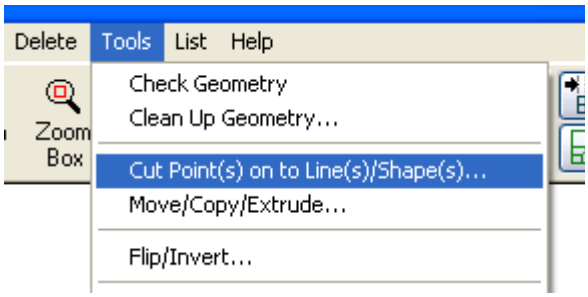


This problem is probably best solved by direct manipulation of the geometry.

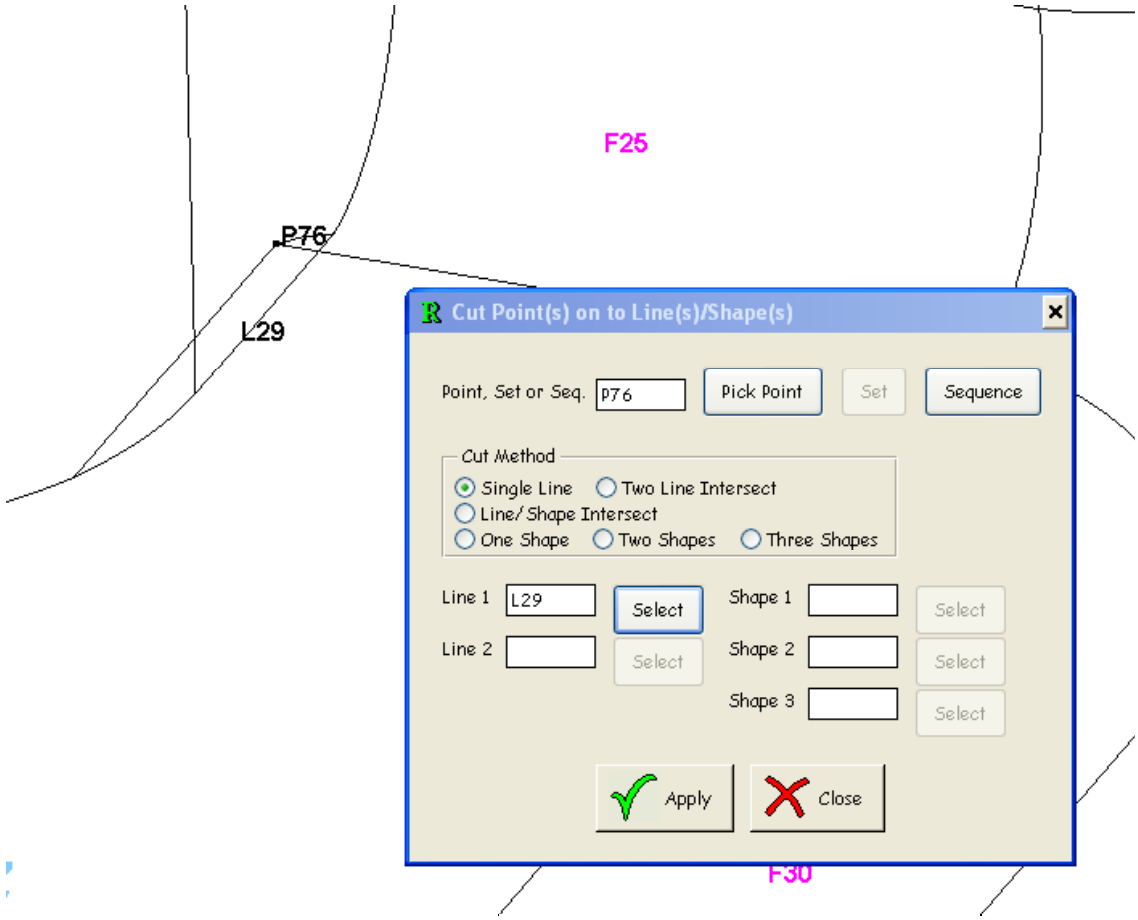
Display the face labels, delete face F4



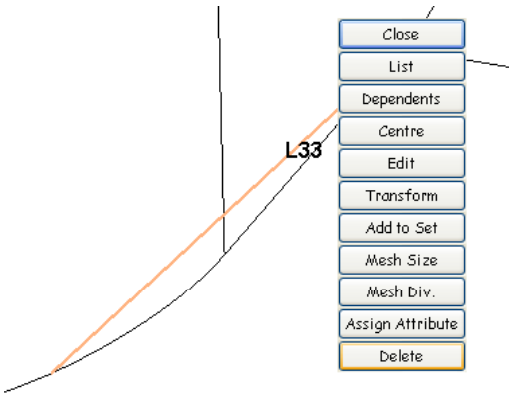
Select the cut point tool.

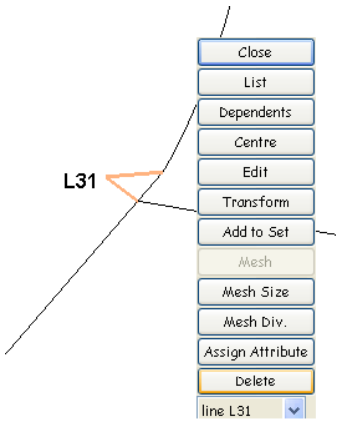


Select the point indicated below and the line to cut the point to.

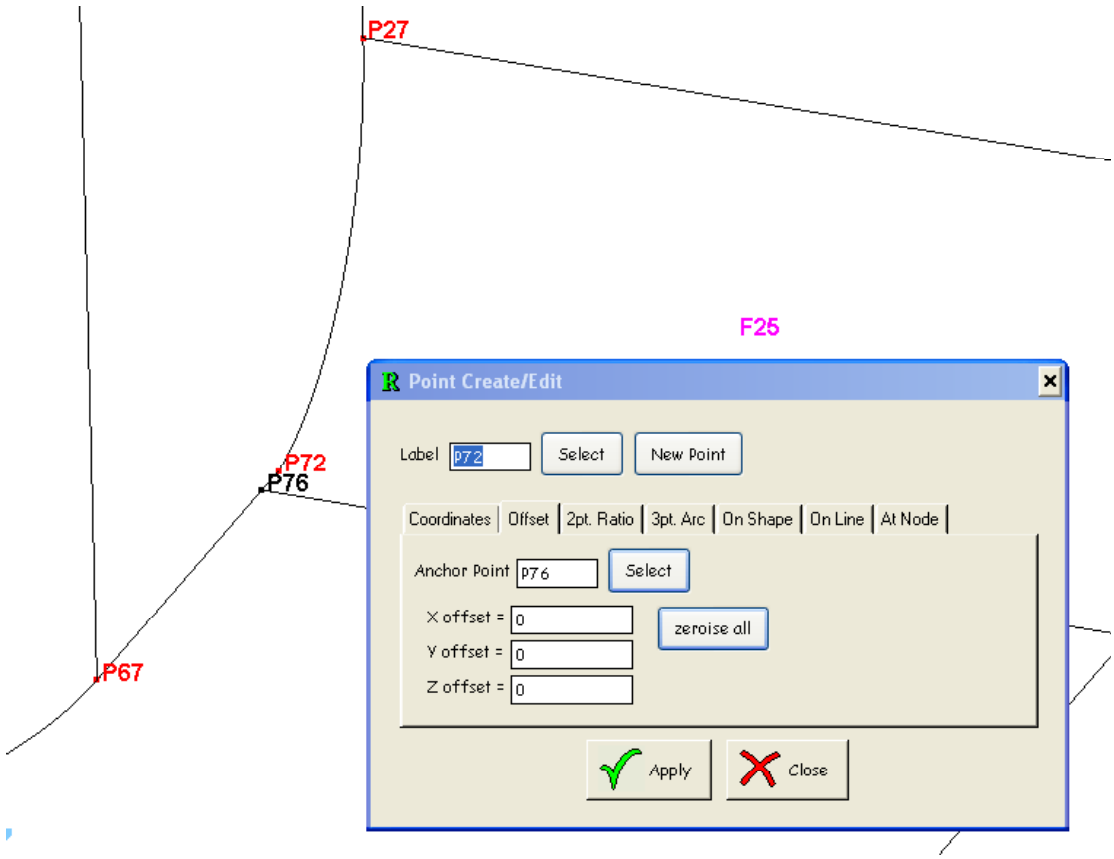


delete the lines shown here

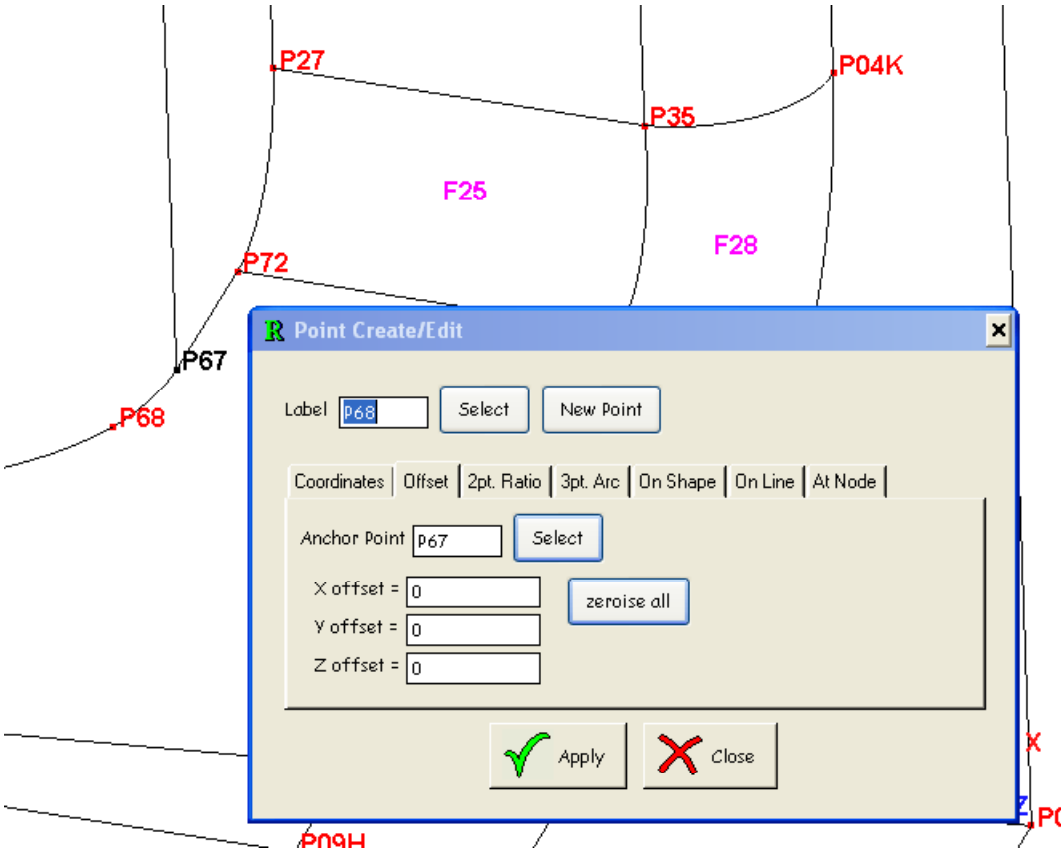




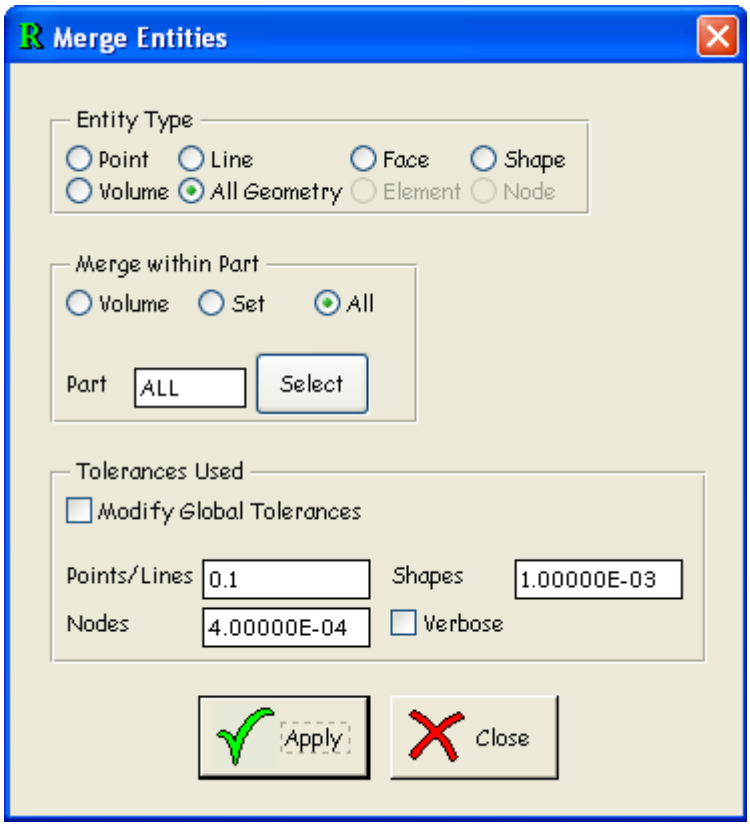
Display point line ends. Move point P72 to be coincident with point P76



Similarly move point P68 on to point P67



Under the tools menu select merge and merge all entities in the model.



Under the tools menu run the check geometry command.

The model meshes with no problems.