BOXERsolutions is acting as an agent for Cambridge Flow Solutions Ltd.

This guide is provided courtesy of Cambridge Flow Solutions Ltd. and subject to Cambridge Flow Solutions Ltd.'s waiver.

BOXER Tutorial:

Axial HPT Blade

BOXER version 3.10.0

For further information please contact.

BOXERsolutions Ltd.
Suite 1
200 Cambridge Science Park
Milton Road
Cambridge
CB4 0GZ
info@boxersolutions.com
www.boxersolutions.com

Axial HPT blade

Note:

In this tutorial, an axial gas turbine geometry, including all the secondary hub and shroud flow paths and the internal cooling geometry, is prepared for analysis.

This tutorial demonstrates the concepts of a cylindrical Bounding Box, and hence the creation of an octree mesh based on polar cylindrical coordinates. There are multiple patch refinements based on local curvature and facet edge angle, and also the use of polylines to identify regions for refinement and viscous layer mesh.

Import the geometry from the NX CAD part `hpt_blade.prt` 

- `File > Import Part` from the menu bar, OR
- Click the Import Part toolbar button, OR
- Use the keyboard shortcut Ctrl-G.
- Select the NX file hpt_blade.prt and press the Open button (or double click on the part filename).
- The Import CAD Wizard window appears, progress is shown as the file loads and then the Import CAD Wizard becomes active.
- Select the following options from the Import CAD wizard:

  For `Face assignment`, select `Colour` and `Parts`, ensure `All Faces` is unselected (`Part Attribute` and `Face Attribute` are not available in this particular model).

  Leave the `Curvature resolution` sliders in their default positions.

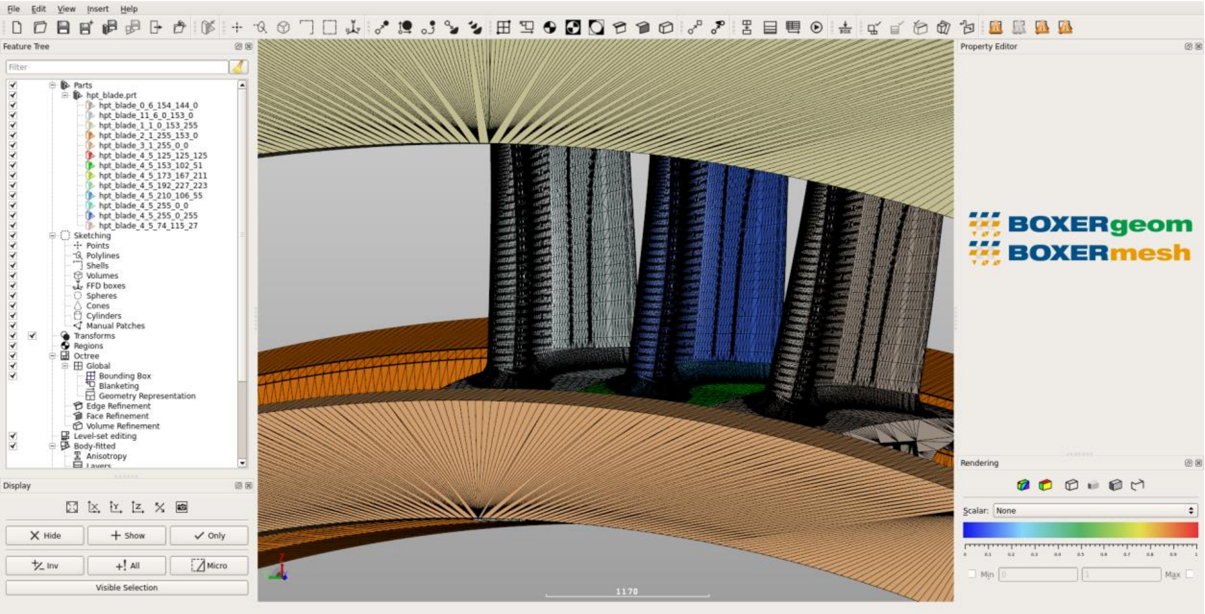
  Enable the `STL-style` radio button.

  Select the `Max. Chord Error` option and enter a value of `0.1`.

  Uncheck `Simplified ASCII Names` ,check `Merge Duplicate Attributes`

  In the Select Layers list, check only layers 1, 5 and 6.
- Click `OK` to complete the CAD import.

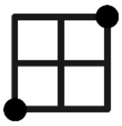
The geometry is imported as a single part ("hpt_blade.prt") containing 13 patches. A default bounding box is set up using the `Constraint: None` option.



At this stage the individual patches have rather generic names based on part list, layer number and original colours used by the NX CAD system. It is useful to rename some of the patches. To rename a patch, RMB over the patch name in the Feature Tree and then LMB "Rename..." from the pop-up menu.

- Rename `hpt_blade_0_6_154_144_0` (1st in the patch list) as `blade1`
- Rename `hpt_blade_11_6_0_153_0` (2nd in the patch list) as `blade3`
- Rename `hpt_blade_4_5_125_125_125` (6th) as `tip`
- Rename `hpt_blade_4_5_153_102_51` (7th) as `hub`
- Rename `hpt_blade_4_5_173_167_211` (8th) as `shroud`
- Rename `hpt_blade_4_5_192_227_223` (9th) as `shroud_fillet`
- Rename `hpt_blade_4_5_210_106_55` (10th) as `hub_fillet`
- Rename `hpt_blade_4_5_255_0_0` (11th) as `trailing_edge`
- Rename `hpt_blade_4_5_255_0_255` (12th) as `blade_surface`
- Rename `hpt_blade_4_5_74_115_27` (13th in the patch list) as `internals`

Rename other patches to more descriptive names if you wish

Define a cylindrical Bounding Box 

This Bounding Box will span one pitch of the 68-bladed annulus in this particular example. By setting the `Cylindrical` option, BOXERmesh automatically sets the mesh on the theta-min and -max faces to be periodic and permits the fixing of the theta extent of the mesh.

- Double-click the `Bounding Box` item in the feature tree, or click on the Bounding Box button in the toolbar to open the Bounding Box Editor.
- From the `Coordinate System` menu picker, select `Cylindrical`.
- Ensure that the `θ-Periodic` box is checked

- Set the `Datum[`*x,y,z*`]` as (500, -700, 10600).
- Leave the `Manual rBar` box unchecked.
- Set `Corner 1` (x,theta,r) as (-1240, 0.4, 10200).
- Set `Corner 2` (x,theta,r) as (2500, -4.89411, 14200).
- Set `Number of Cells` to 40.
- Click `OK` to confirm the Bounding Box specification.

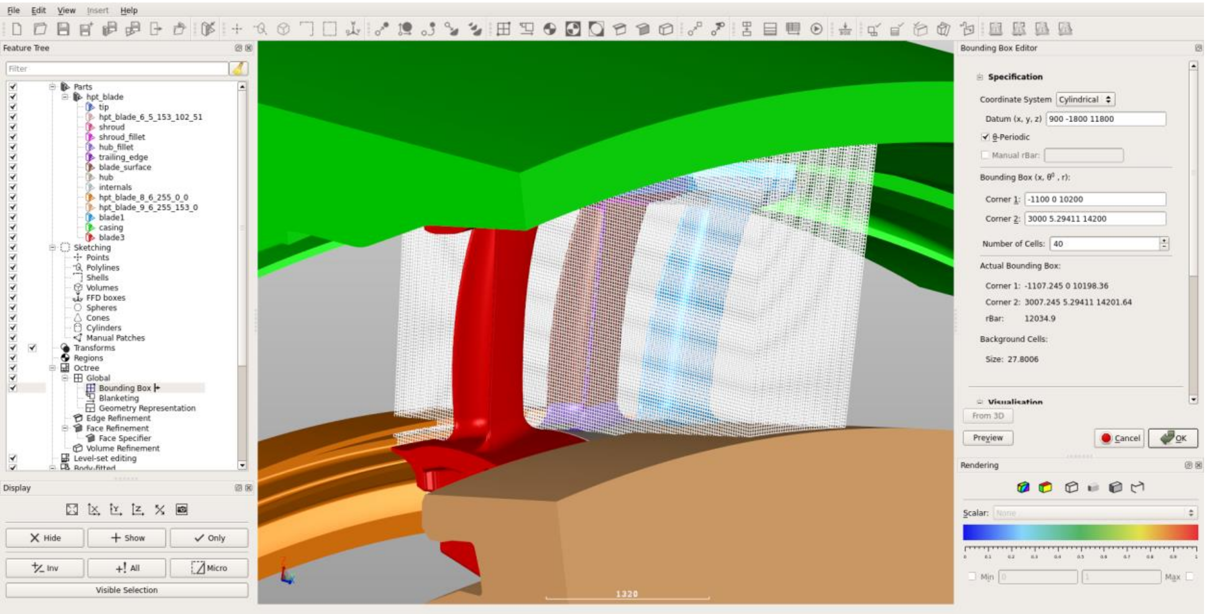
The Bounding Box appears in the scene, subdivided by lines which illustrate the number of cells in the tangential direction specified. The user could proceed and generate a mesh defined by this Bounding Box but this is likely to be in the region of 80m cells. Instead, the Bounding Box is resized for this tutorial to keep the cell count manageable.

- Double-click the `Bounding Box` item in the feature tree, or click on the Bounding Box button in the toolbar to open the Bounding Box Editor.
- Set `Corner 1` (x,theta,r) as (-500, 0.4, 12000).
- Set `Corner 2` (x,theta,r) as (1500, -4.89411, 12200).

Use the RMB menu over the Bounding Box entry in the Feature Tree to hide, show and change the display type of the Bounding Box in the scene.

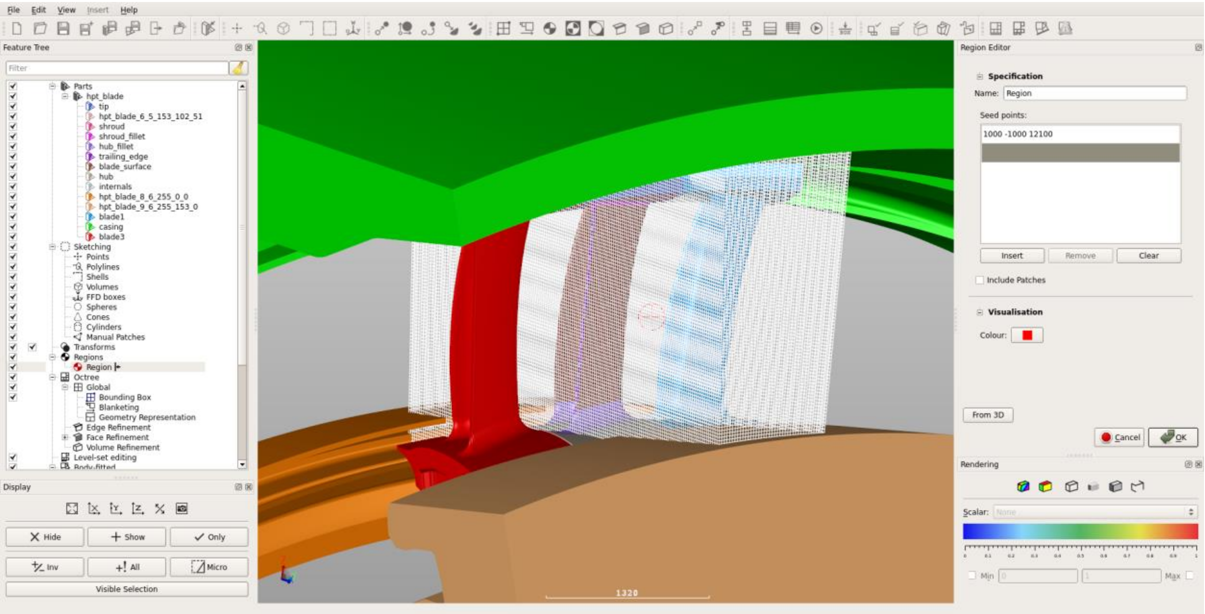
Tip:

With the `Manual rBar` checkbox unchecked, BOXERmesh automatically calculates an rBar value that is close to the middle of the domain in the radial direction. This is beneficial to the final mesh quality.



Define a Region inside the Bounding Box and also in the main gas path. 

- Create a Region and set its seed point coordinates to be (1000 -1000 12100). The default name of the first created region is "Region".
- Click `OK` to confirm the Region specification. A Region entity appears in the Feature Tree, and the Region appears via its seed point as a quartered circle in the 3D scene. Turn off the visibility of the Bounding Box to see it clearly.



Set the `Blanketing` depth 

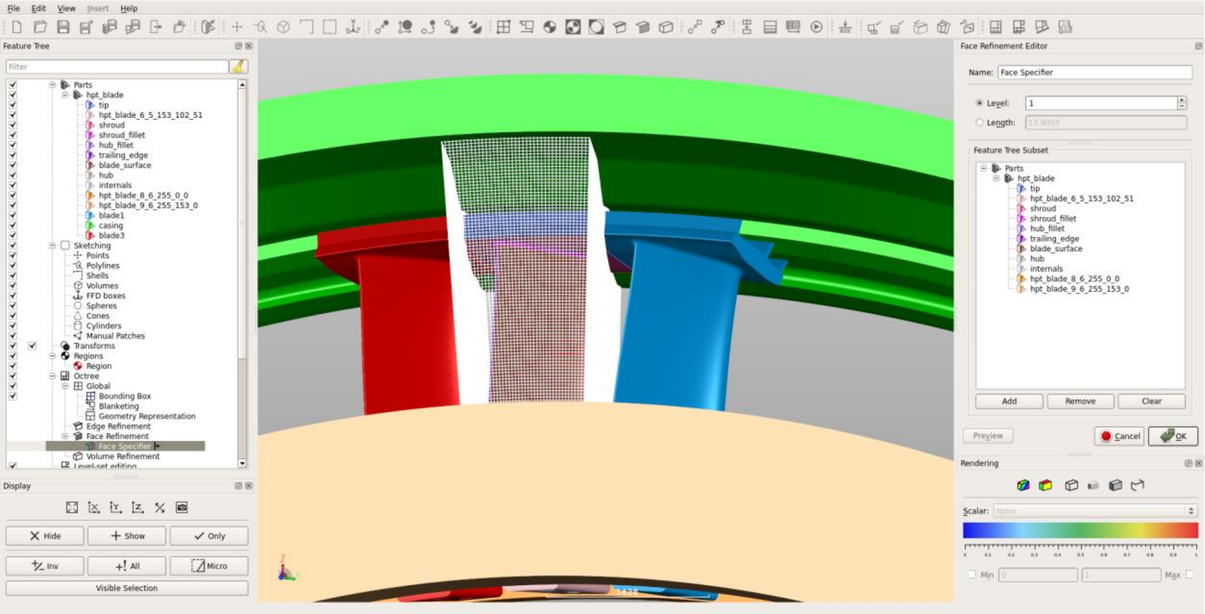
- Open the Blanketing property editor, either by double-clicking it in the Feature Tree or by using the toolbar.
- Untick `Use Default`, and enter `4` in the `Layer Depth` field.
- Click `OK` to confirm the Blanketing specification.

Set a "general" surface refinement level 

- Create a Face Refinement specifier for all the patches, at octree level 1.

Note:

In this example, most surfaces will have refinement greater than level 1. But we can create a "catch-all" refinement specification like this to start with, because BOXERmesh uses the highest level of octree refinement (i.e. the dimensionally smallest mesh length specification) that is specified for any entity, ignoring any lower level (coarser mesh) that might be specified elsewhere.



Set Face Refinement on specific patches 

- Create a Face Refinement Specifier on patch "blade_surface" at octree level 2.
- Create a Face Refinement Specifier on patches "internals", "hub", "shroud", "hub_fillet", "shroud_fillet", “blade1” and “blade2” at octree level 3.

Set Edge Refinement on specific patches 

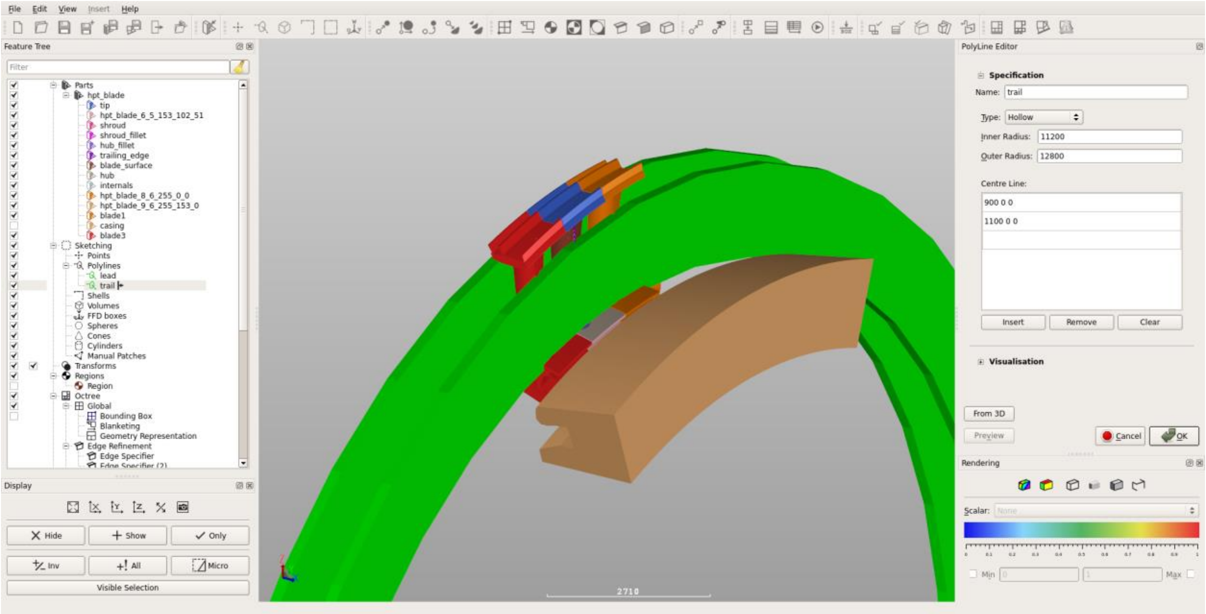
- Create an Edge Refinement Specifier on patches "internals" and "tip", at octree level 4 for edges with a minimum angle deviation of 30 degrees.
- Create an Edge Refinement Specifier on patch "internals", at octree level 4 for edges with a maximum radius of curvature of 10.0.

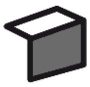
Create three polylines to enclose the surfaces around the blade leading edge and trailing edge

- Create a hollow Polyline called "lead"; with `Inner Radius` of 11200, `Outer Radius` of 12850, using a starting point of (-100, 0, 0) and end point of (100, 0, 0).
- Create a hollow Polyline called "trail"; with `Inner Radius` of 11400, `Outer Radius` of 13100, using a starting point of (900,0,0) and end point of (1100,0,0).

Note:

The Polyline castellation error in the image below - piecewise-linear resolution of the cylinder boundaries - is only an artefact of the GUI rendering resolution and not of the Polyline data itself.

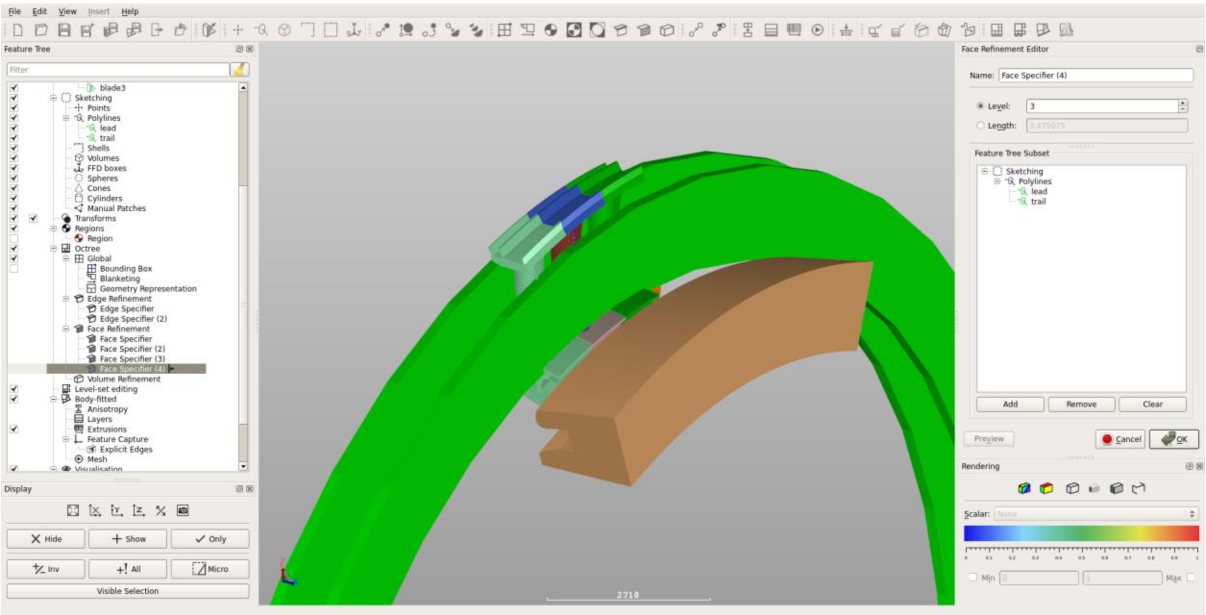


Use the Polylines as Face Refinement specifiers 

- Create a Face Refinement specifier using all the geometric patches and the Polylines "lead" and "trail", at octree level 3.

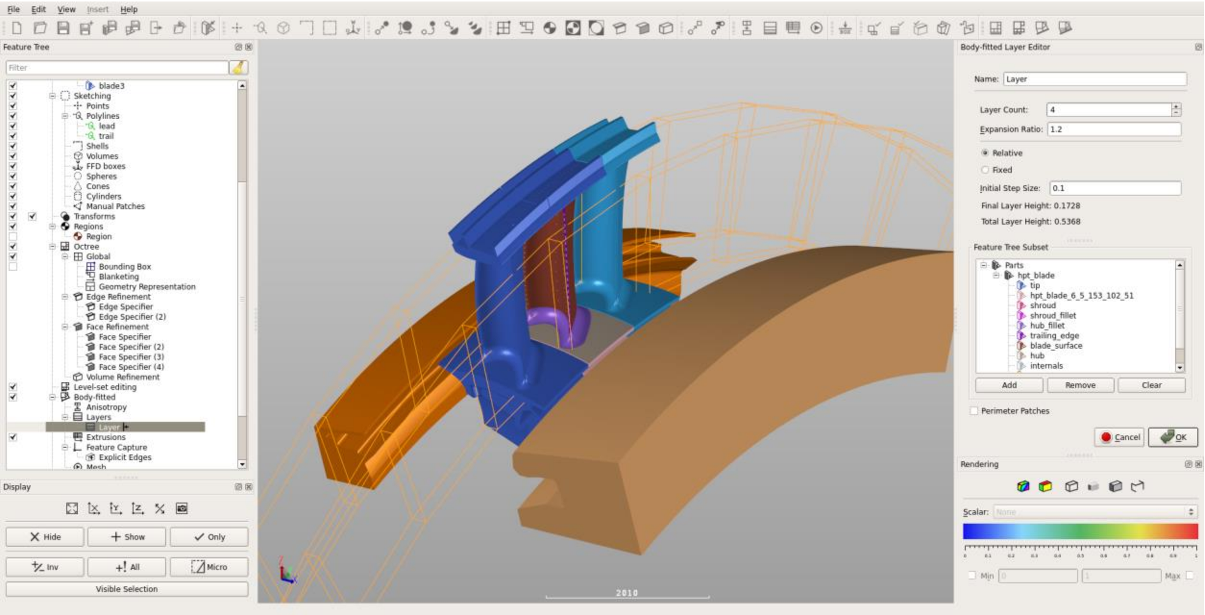
Note:

It doesn't matter that all the specified geometry doesn't intersect with the polylines. BOXERmesh automatically works out where the intersections between geometry and polylines occur, and applies the specified refinement at those surfaces only.



Create a global Layer Specification

- Create a Layer Specification for all patches; using `Layer Count` as `4`, `Expansion Ratio` as `1.2`, and `Initial Relative Step Size` as 0.1.
- Do not use the `Perimeter Patch` option.



Define a feature capture angle

- Open the Body-Fitted Mesh editor by clicking the Edit body-fitted mesh setup button on the toolbar.
- Check the Feature Capture option is enabled.
- Change the `Angle` to `30`.
- Click `OK` to confirm the Body-Fitted Mesh specification.

Note:

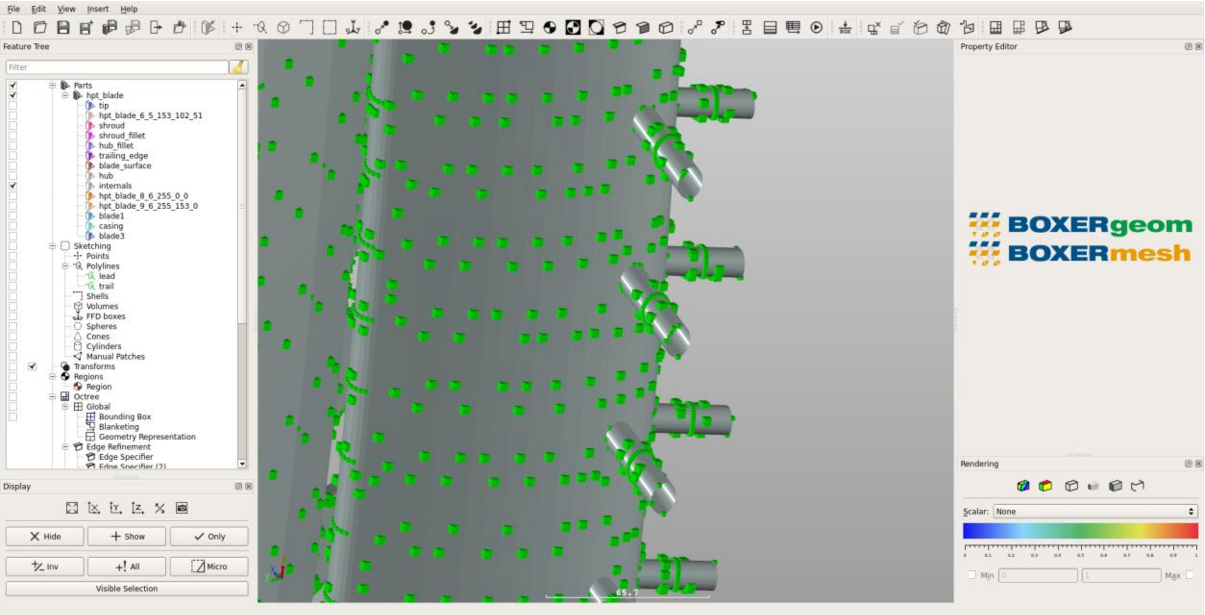
If saving the full mesh specification to a script file for later batch processing, the Body-Fitted Mesh Editor is used to supply the output mesh file name in the script - via the `Save Mesh in Script` checkbox and the `Name` field.

Check basic cell sizing using the Octree Preview function

- From the toolbar, turn on Octree Preview.
- Indicative cubes appear, scattered across the surfaces to be meshed. The cubes are at the same length scale as will be the local octree mesh.
- Zoom in to near the cooling holes, and check the local mesh length scale against the geometry hole diameter. Turn off visibility of the "blade_surface" part to see the holes more clearly.

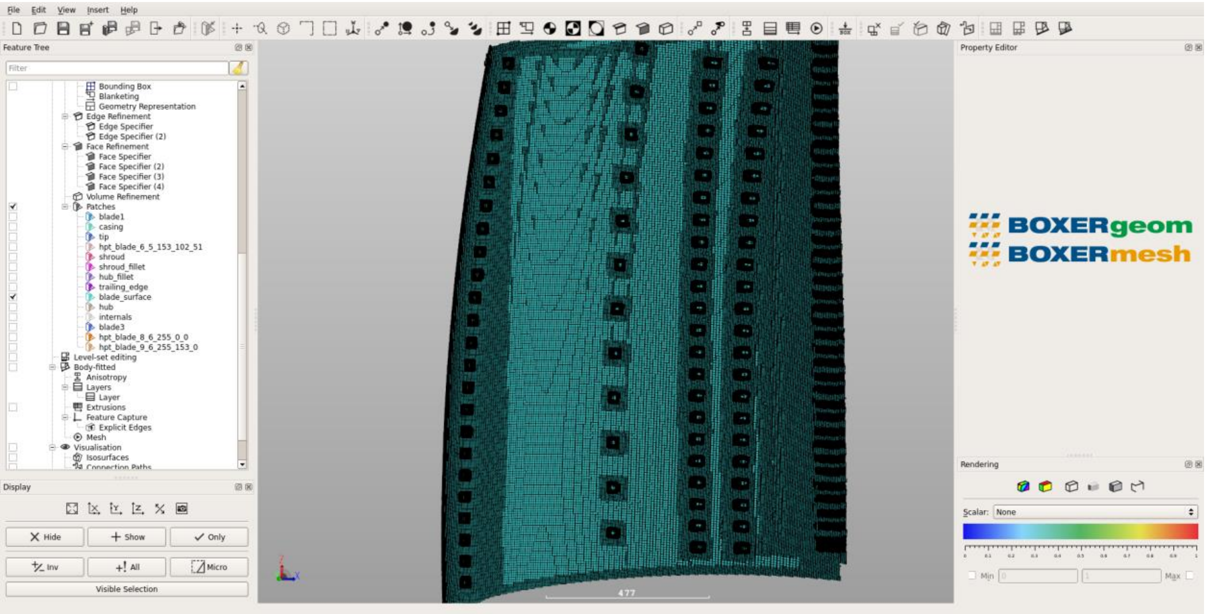
Note:

There are two length scales shown on the holes, one relating to a Face Refinement Specifier (level 3) and one to an Edge Refinement Specifier (level 5). The smallest local cell size takes precedence, so in this case the Edge Specifier 'wins' near the holes.

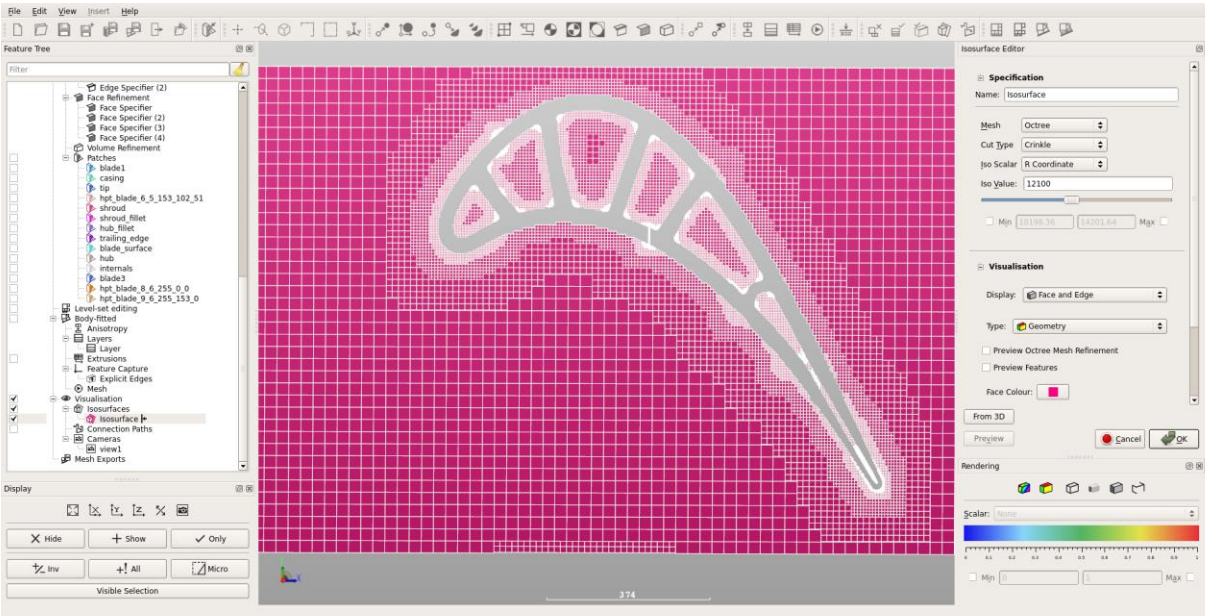


Generate and view the Octree Mesh 

- Click on the Generate Octree Mesh button in the toolbar (*the button goes orange to indicate that BOXERmesh is busy*)
- When the octree mesh is complete, the Generate Octree Mesh button goes grey and its action is disabled to indicate that the octree is up-to-date.
- The internal octree patches appear in the scene and also appear as features in the Feature Tree.



- Click on the Generate New Isosurface button in the toolbar, or go `Insert > Isosurface` to open the Isosurface Editor dialog. 
- Change the `Mesh` type to `Octree`, change the `Cut Type` to `Isosurface` and change the `Iso Scalar` to `R Coordinate`.
- Enter an `Iso Value` of `12100` and click `OK`. A cut plane through the Octree volume mesh appears at R=12100.
- The item `Isosurface` appears in the Feature Tree under `Visualisation > Isosurfaces`. To see it more clearly, turn off the visibility of all parts and octree patches; or RMB over `Isosurface` and select "Only" to remove everything from the view except `Isosurface`.
- Enter different values of `R Coordinate` to "sweep" through the volume mesh.

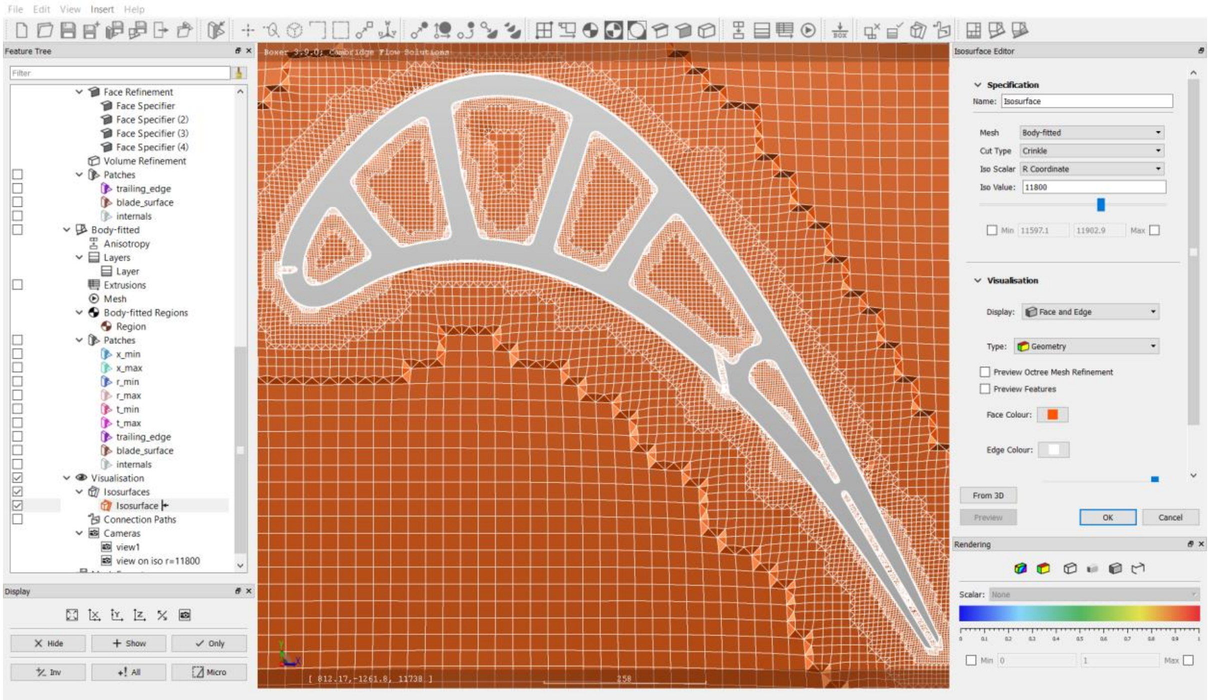


Generate and view the Inviscid mesh 

- Click on the Generate Inviscid Mesh button in the toolbar (*the button goes orange to indicate that BOXERmesh is busy*)
- When the mesh is complete, the Generate Inviscid Mesh button goes grey and its action is disabled to indicate that the mesh is up-to-date.
- The surface mesh patches appear in the scene and also appear as features in the Feature Tree.
- Double-click on `Isosurface` in the Feature Tree to re-activate the Isosurface Editor for this feature.
- Change the `Mesh` list picker from `Octree` to `Body-Fitted`, change the `Cut Type` to `Crinkle` and click `OK`. The visualisation changes to show a slice through the body-fitted mesh.

Generate and view the Layered mesh 

- Click on the Generate Layered Mesh button in the toolbar (*the button goes orange to indicate that BOXERmesh is busy*)
- When the mesh is complete, the Generate Layered Mesh button goes grey and its action is disabled to indicate that the mesh is up-to-date.
- The Isosurface updates and the layers can now be seen.



Save the mesh (`*.box`) on the server filesystem 

- Go to `Insert > Mesh Export` and select `BOX` to open the BOX Mesh Export Editor dialog. Alternatively, click the `Create new BOX mesh export specification icon` on the toolbar.
- Leave the name as default `BOX Mesh Export`.
- Click on the disc icon to open a file browser. Navigate to the working directory, enter the filename `hpt_blade_air` and check the `Automatically Save with File-Extension (*.box)` tick box. Click `Save`.
- Ensure the `Enabled` tick box is checked.
- Drag the region that contains the mesh ("`Region`") from the Feature Tree and drop it in the `Exported Regions Subset` in the BOX Mesh Export Editor.
- Click `OK` to exit.
- (Optional) Repeat the above to export the same mesh in an alternative format.

- Click on the `Save all body-fitted mesh exports` button in the toolbar, or
- `File > Save all mesh exports` from the menu bar.
- Check that you have a `.box` file.

Save the geometry file (`*.btf`) and the project file (`*.bxr`) on the client filesystem

- `Save` from the menu bar, OR
- Click on the Save Project icon on the toolbar, OR
- Keyboard shortcut Ctrl-S.
- The geometry must be saved before the project and a pop up window informs the user of this. Click `OK` and save the the geometry (*.btf) file.
- The `Save Project As` window now opens. Click on the `Project` disc icon to open a file browser. Navigate to the working directory, enter a project filename and check the `Automatically Save with File-Extension (*.bxr)` tick box. Click `Save`.
- If you wish to save a `.bmf` file then check the `Mesh` tick box.
- Click on the `.bmf` disc icon to open a file browser. Navigate to the working directory, enter a `.bmf` filename and check the `Automatically Save with File-Extension (*.bmf)` tick box. Click `Save`.
- Click `OK` to save the project file and `.bmf` file.