



3DPRINTING EXERCISE

Volume Lattice

Tutorial_V7- Updated: 16,0000,1830,371(Official)

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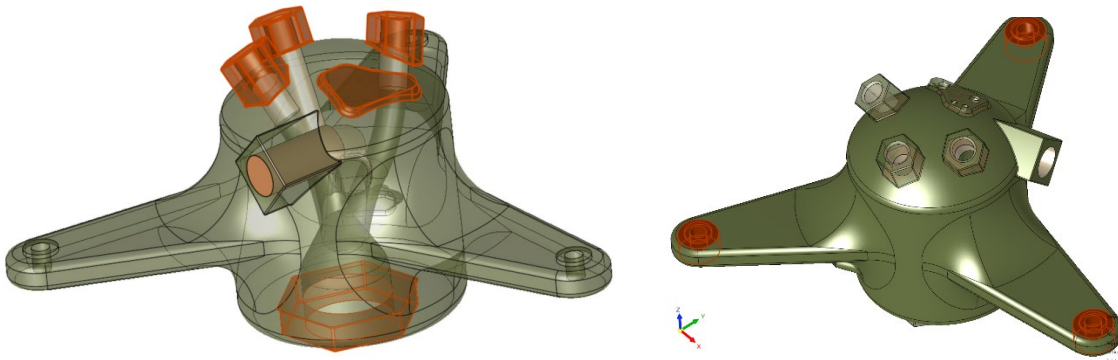
3DXpert includes tools for topology optimization, Lattice and Infill.

This enables to create an internal structure of the part (keeping its outer skin) that will save weight, material and printing time, while keeping the designed strength of the model.

This exercise discusses Lattice.

Part 1 – Creating the Lattice

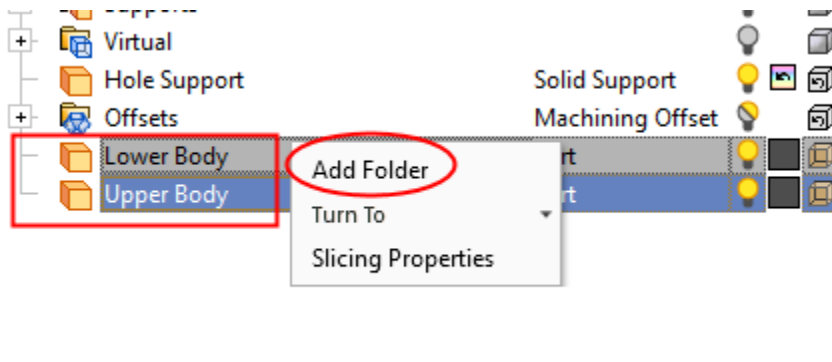
1. Unpack the file **3DXpert - Part Lattice** and load the file **Exercise2.elt**.
2. The main part is divided into several objects (the upper geometries belong to a single object):



These objects were separated from the part as we do not want the lattice in them.

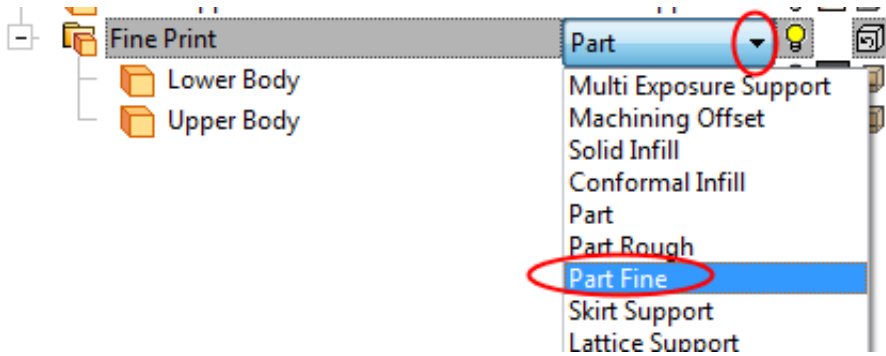
Also the 3 bosses shown in the image to the right were separated from the part as we do not wish to create a lattice through them.

3. In the object tree, select the two new objects (they are added at the bottom), right mouse click and select **Add Folder**



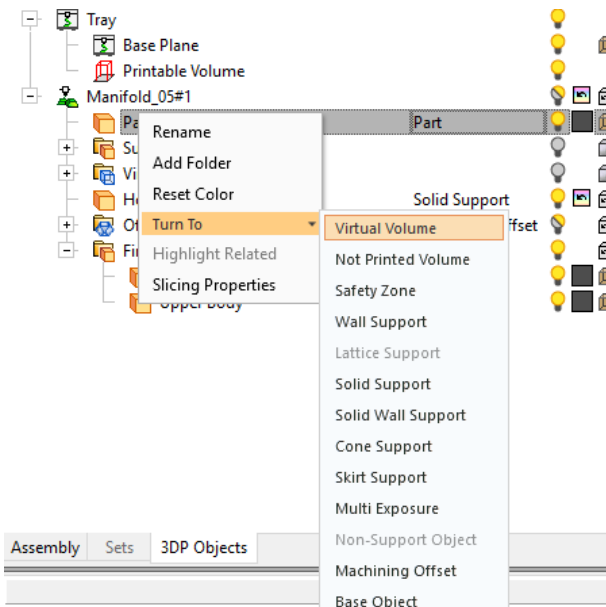
4. The objects will now be added to this folder. Rename it **“Fine Print”**. You can hide or show them together through the folder’s light bulb.

- Assign the Technology **Part Fine** for these objects through the tree.



More on assigning technology:

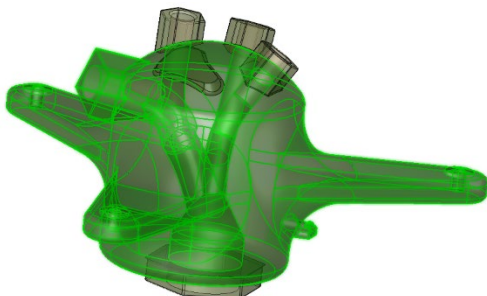
It is possible to define an object as Virtual Volume or Not-Printed Volume through the Objects Tree. Turning objects to Not-Printed Volumes can be an easy way to exclude parts from printing, if needed. Right mouse click the object on the tree and select the option from the context menu.



By selecting the 'Turn To...' functions, Not-Printed and Virtual objects are also automatically placed in their matching folders on the Objects Tree.



- From the Menu, press the **Create Lattice** button
- Pick the main part.



The Lattice interaction includes many options. First review how the dialog is set:

#1 - Lattice Type - in this section we define how the lattice cells are organized. The type generally controls the propagation behavior of the cell.

#2 - Cell Definition - in this section we set the cell's definition and parameters like cell structure, size, node and connector types and size. A preview picture showing the cell structure is shown at the bottom of that section.

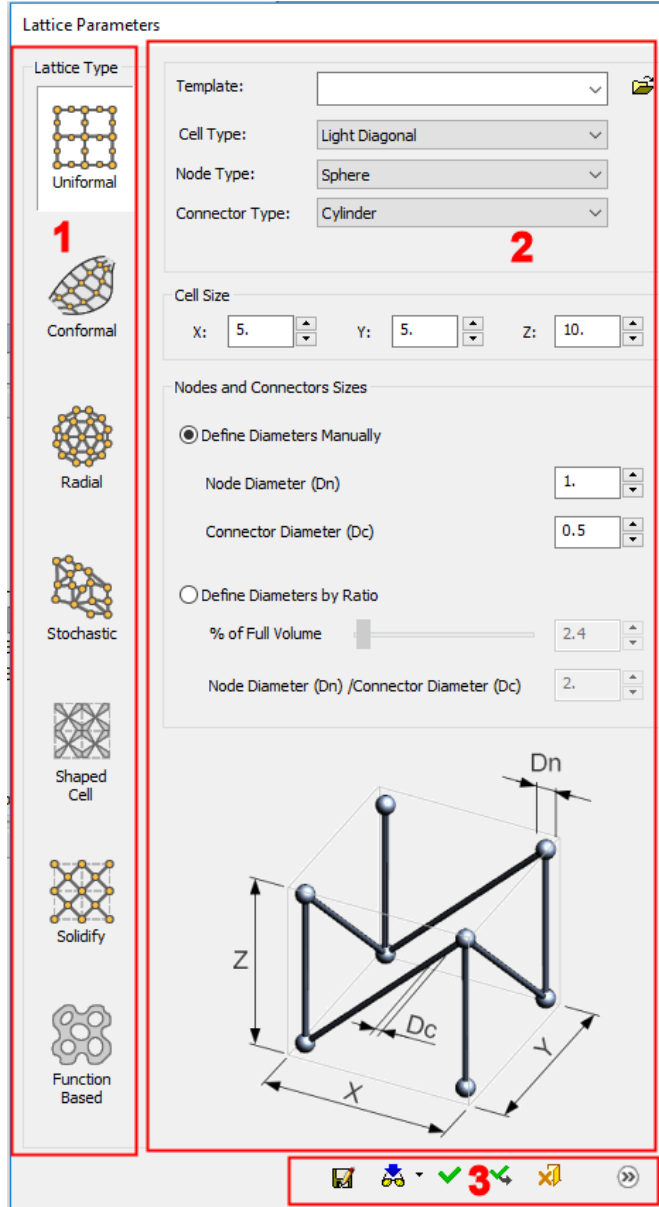


Node: The basic building block.

Connector: The string or face connecting nodes.

Cell: The building block of a lattice composed of nodes and connectors.

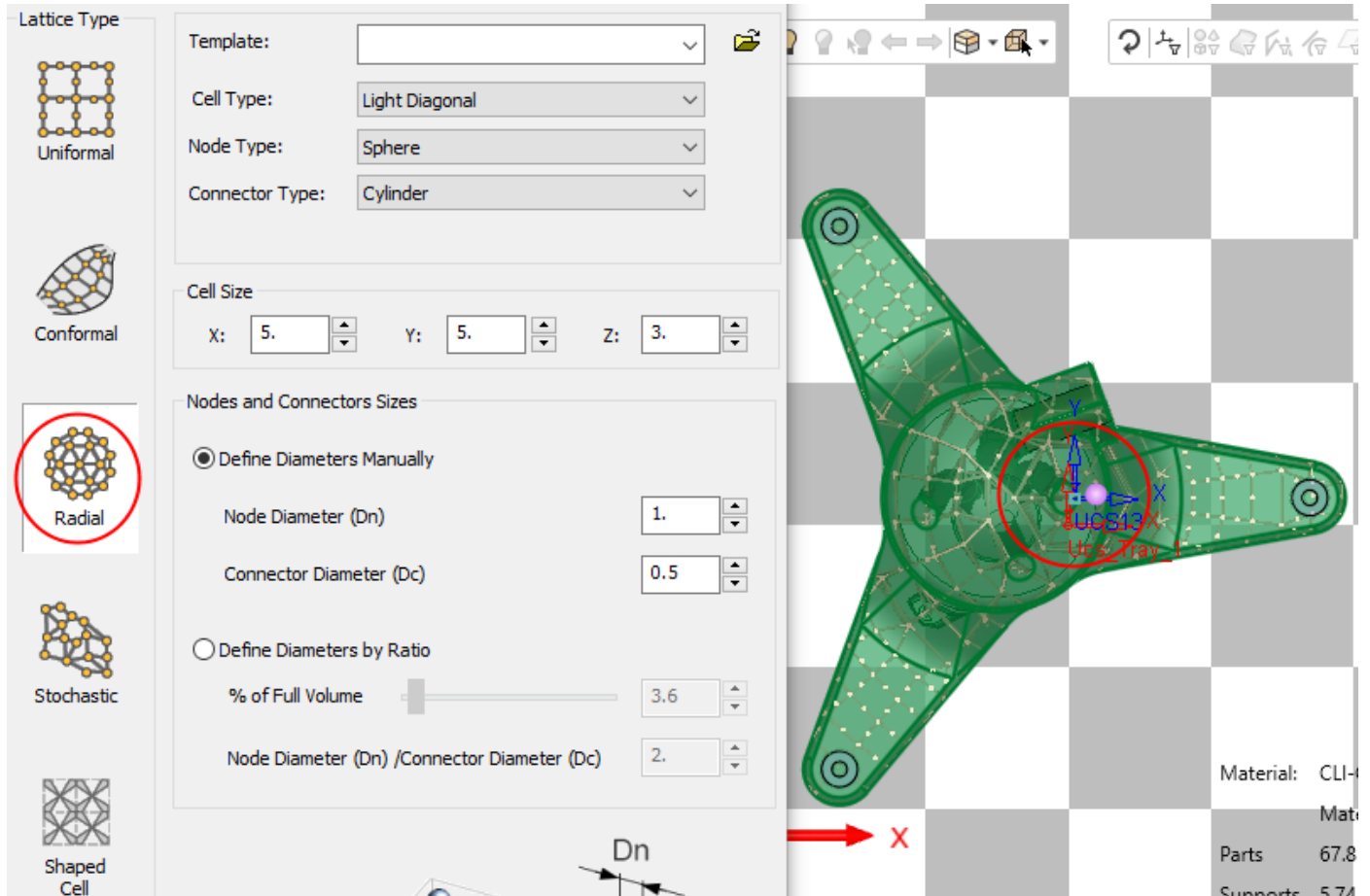
#3 - Action Buttons Bar - OK, Show Preview, Cancel etc...



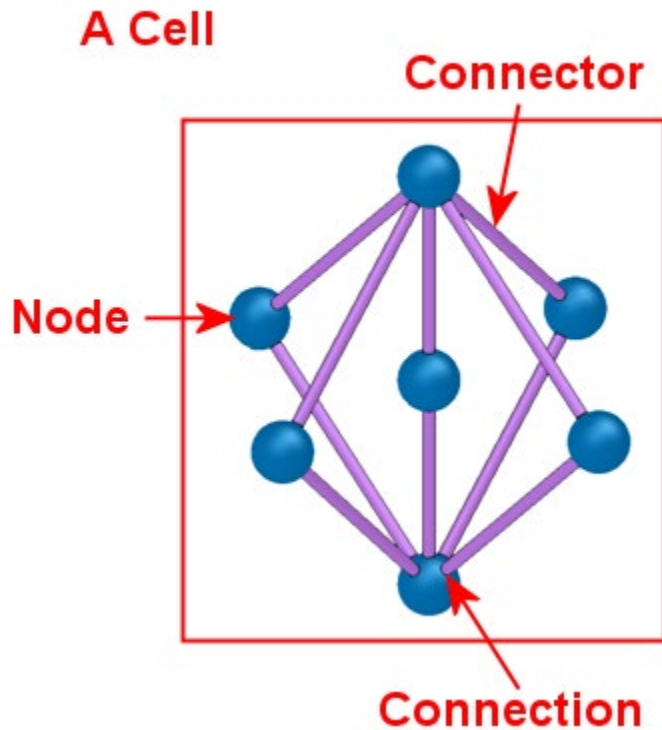
The Lattice Type, as mentioned before, controls the propagation behavior of the cell, the way it is spread out in a defined volume.

The **Uniform** type shows uniform propagation in the XYZ direction. The system places the cells one next to each other.

The **Radial** type shows a radial propagation which starts at the **UCS origin point**. In this structure, the cells are built from the inside outwards from the center; starting with triangles, and then building the diagonal cells, enlarge them at every propagation outwards. Once the cell (edge) becomes too big, we resize it and start over.



The number of nodes and connectors, and the relations between them in space define a cell type.



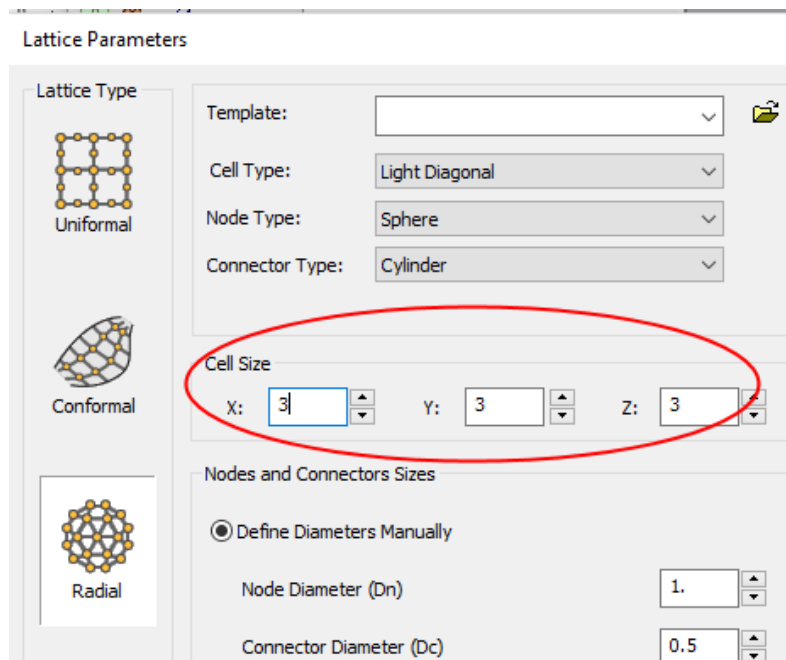
There are several default cell types available, as you can see by selecting each one from the Cells' list. All are printable, meaning they do not require supports for the connectors.

It is also possible to add your own cells. This is discussed in a separate exercise.

Let's review some of the options available in Lattice.

8. Keep the type as **Radial** and the Cell Type as **Light Diagonal**.

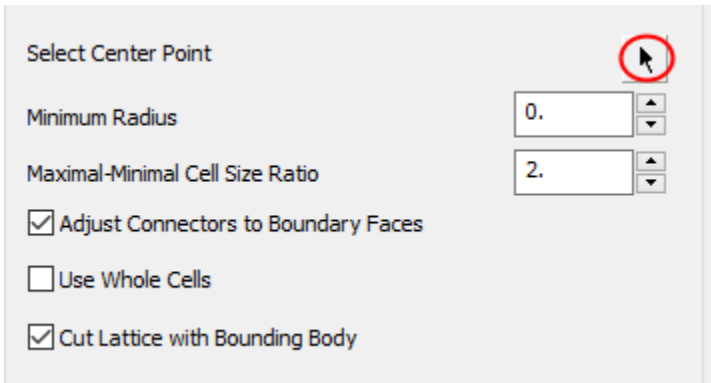
9. Define the size of the cell (X,Y,Z).



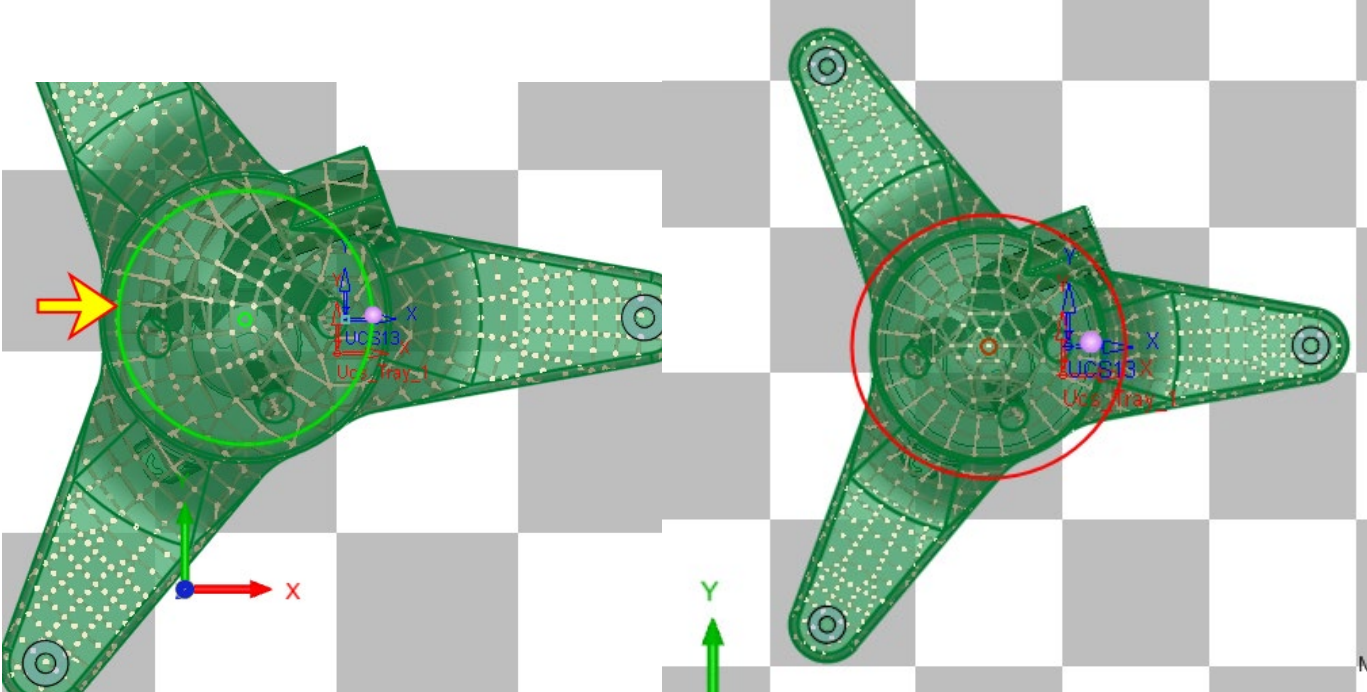
10. **Expand** the dialog to show additional data



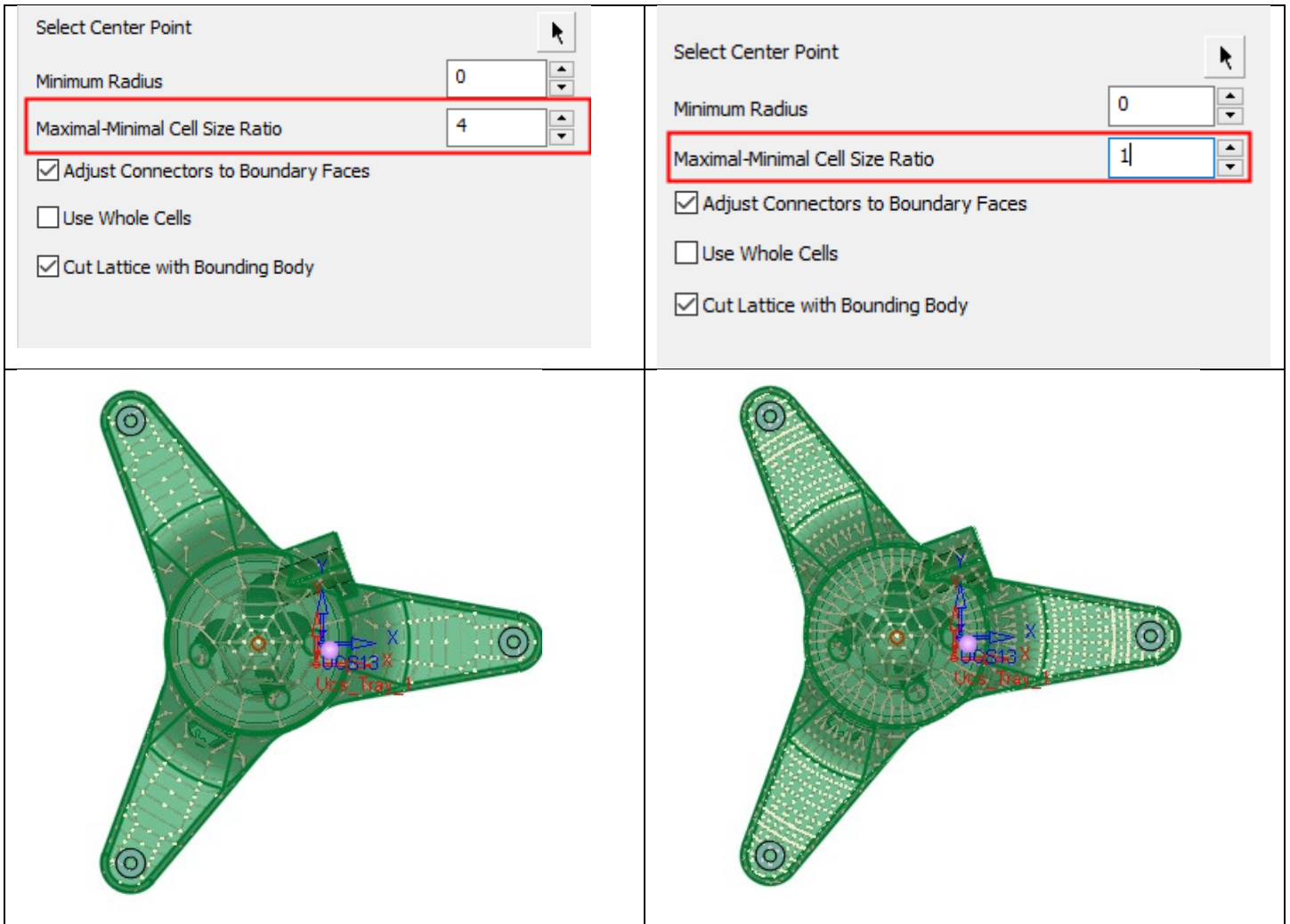
11. First, select another center point of the lattice. An axis in Z is displayed; this is the center axis of the lattice. If a center point is not selected, the center point of the bounding box of the selected object is used. Select the adjacent button:



12. Select the circle center point as the new center point.



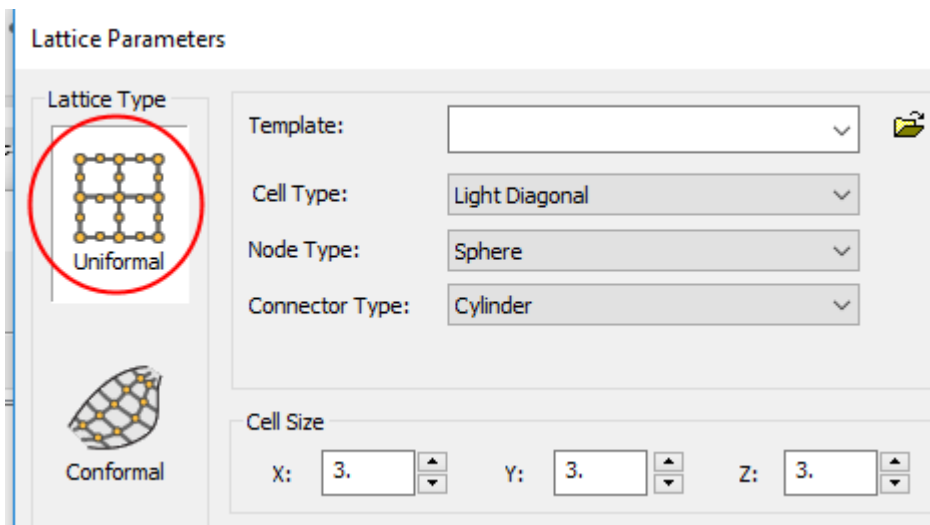
13. In order to adjust the cell size to the changing radius, the user has to set a maximal fluctuation allowed in the width of the cell. Change the Maximal-Minimal Cell Size Ratio to examine the changes in the cells.



14. Set the radius in which the lattice starts. Change between 3 to 0. Finally set it to 0.



15. Set back to the Uniform type.



16. Check the Randomize option. This option enables the user to randomize the lattice structure. A slide bar is available to set the **Randomization Level**.

Randomize

☒ Randomize

Randomization level 0.5

Maximal-Minimal Thickness Ratio

Reshuffle Nodes & Connectors

Variable Thickness

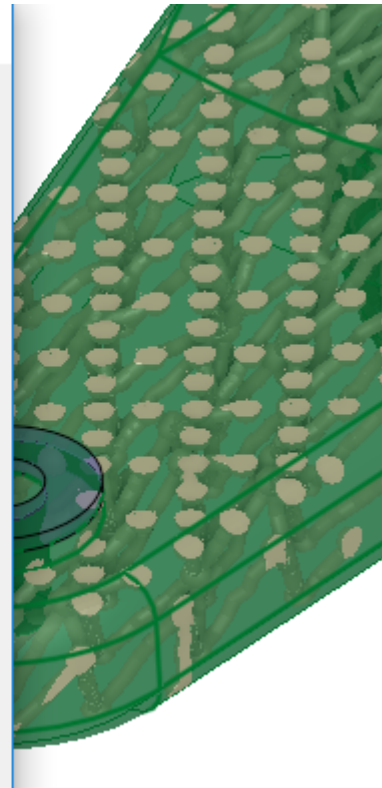
Variable Thickness:

Maximal-Minimal Thickness Ratio

☐ Adjust Structure for Sintering

☒ Use Material Parameters

☐ Define Parameters Manually



17. Uncheck the option to use the Uniform lattice type.

Randomize

☐ Randomize

Randomization level 0.5

Maximal-Minimal Thickness Ratio

Variable Thickness

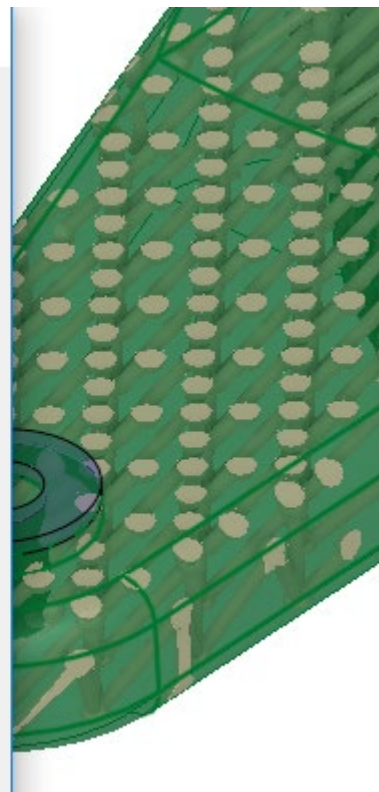
Variable Thickness:

Maximal-Minimal Thickness Ratio

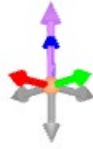
☐ Adjust Structure for Sintering

☒ Use Material Parameters

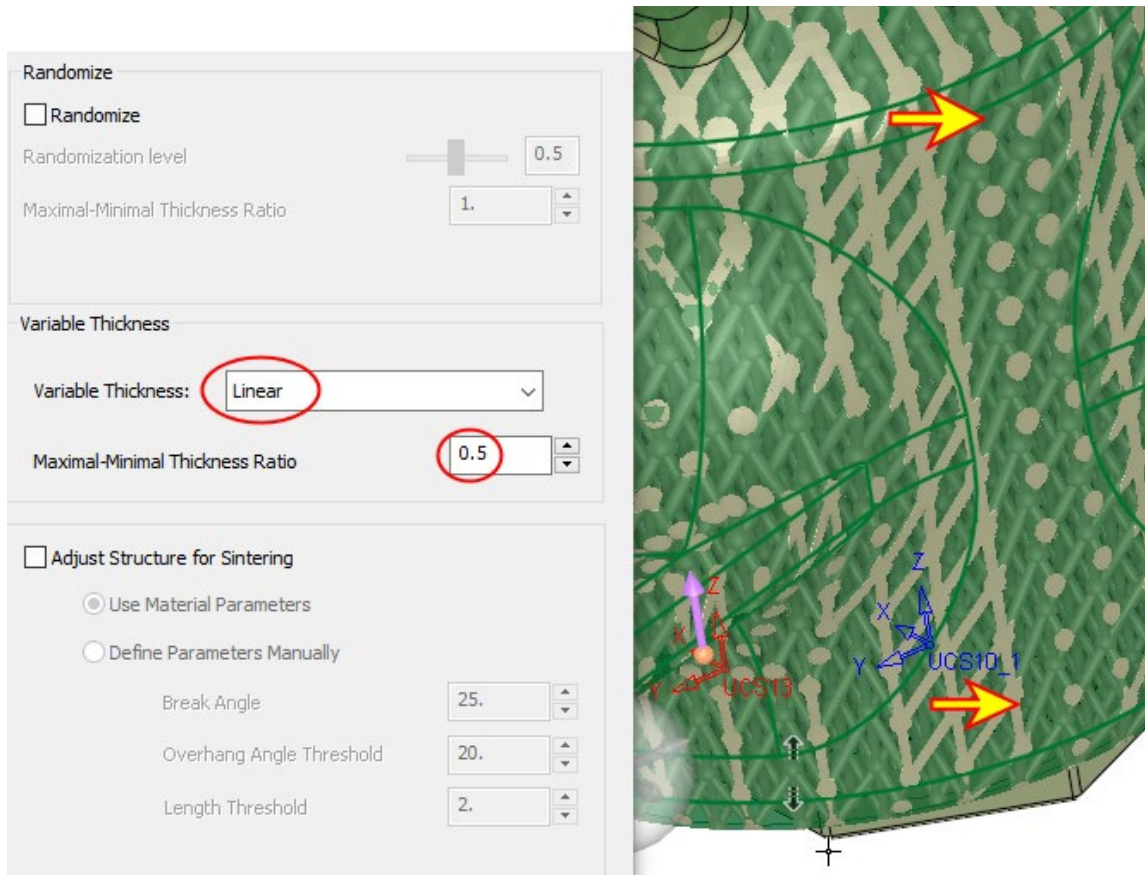
☐ Define Parameters Manually



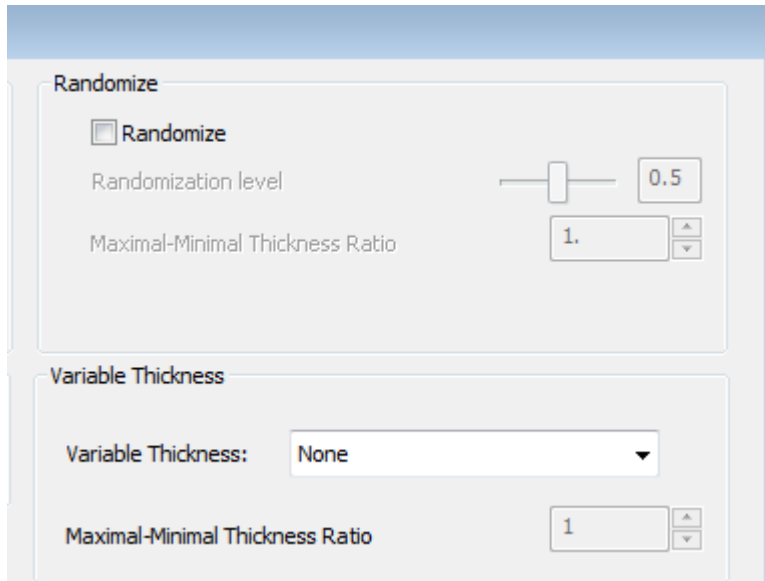
The variable lattice has two options. The first is the linear lattice, which means that the Lattice is changing in size from top to bottom or vice versa, according to the direction of the lattice. (You can set a direction for the lattice using the Standard direction arrow).



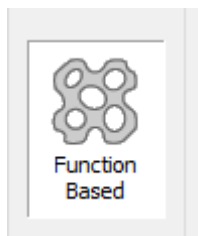
18. Try using the variable thickness. This option create a variable lattice in the Z direction going from thick (up) to thin (down).



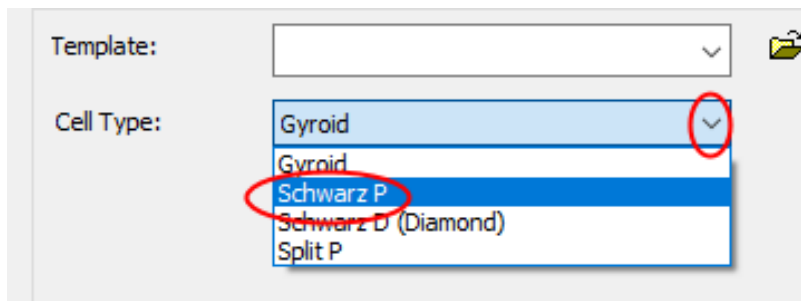
19. Set back to the **None** option.



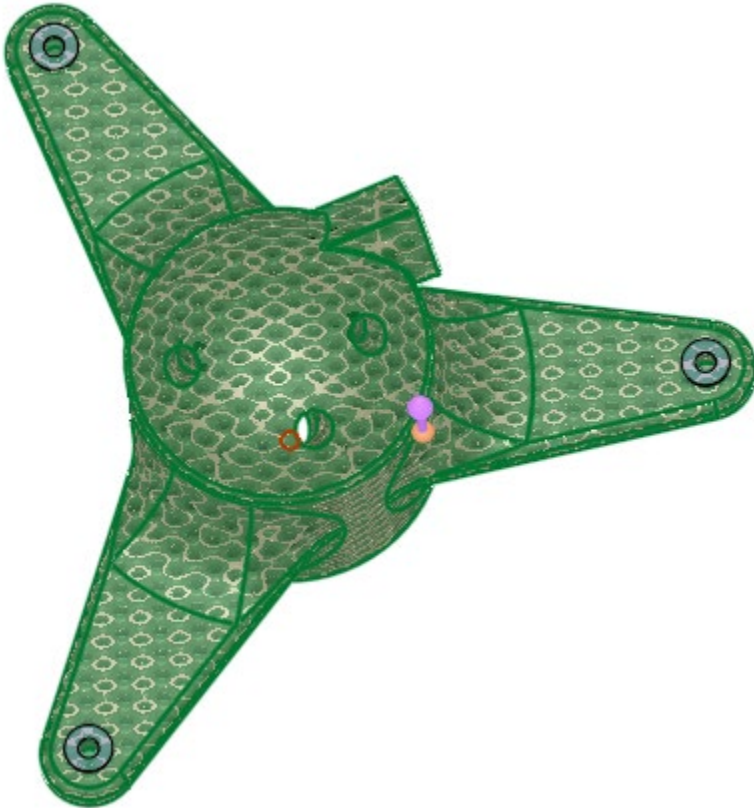
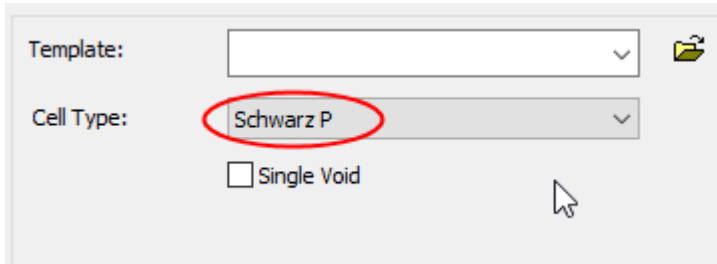
20. Set the Function Based option.



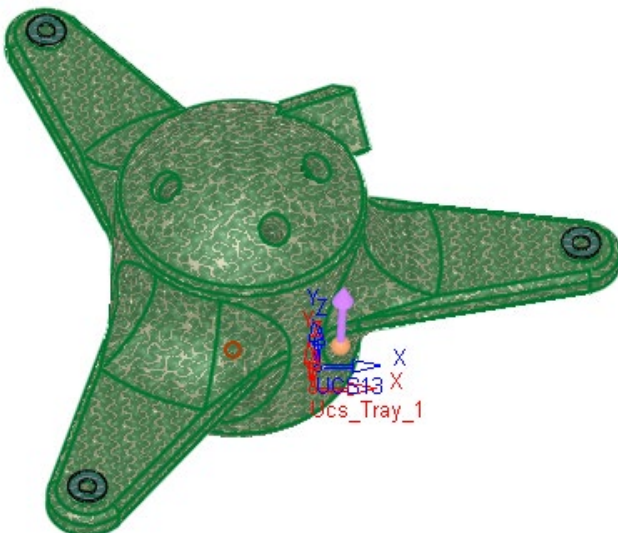
21. Note the available cell types.



22. Select the Schwarz P option.



23. Change the type to Gyroid option.



24. **Define Thickness by Ratio**; define the thickness of the lattice structure by setting a percentage of the full volume that the volume of the lattice will consume. Set the **thickness** to **20** percentage of the full volume.

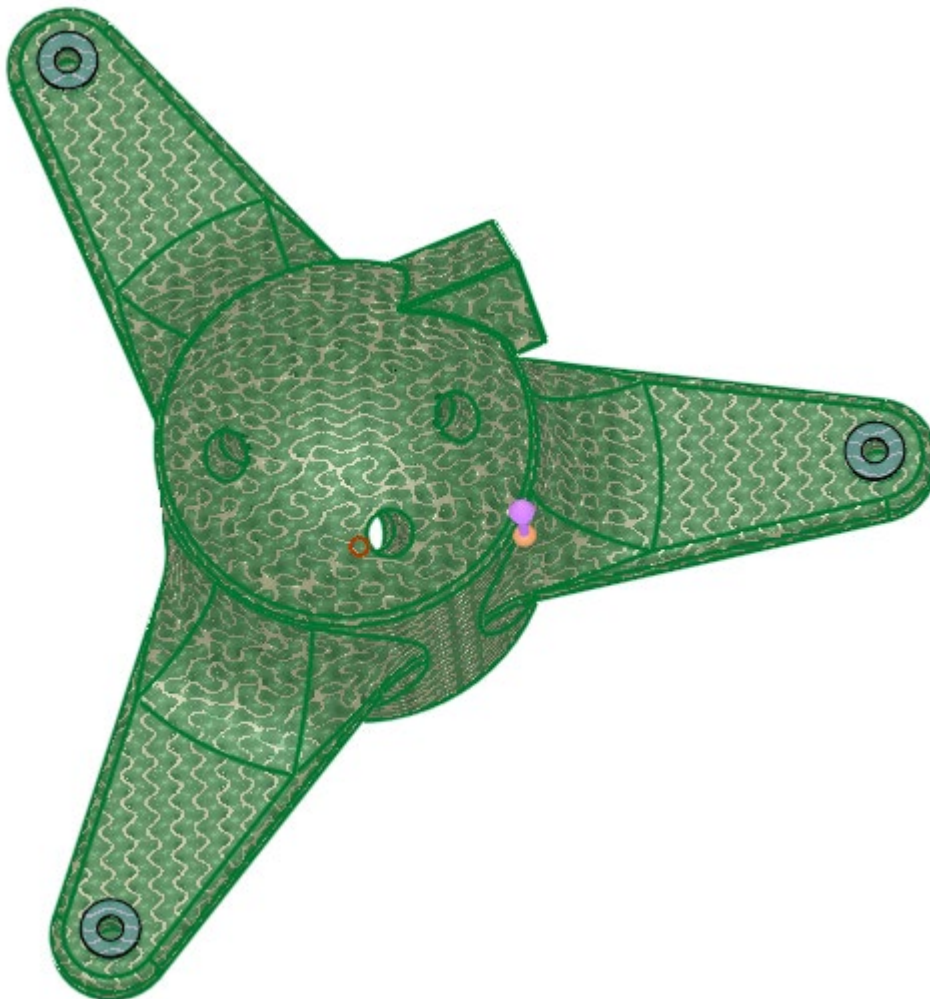
Thickness

☐ Define Thickness Manually

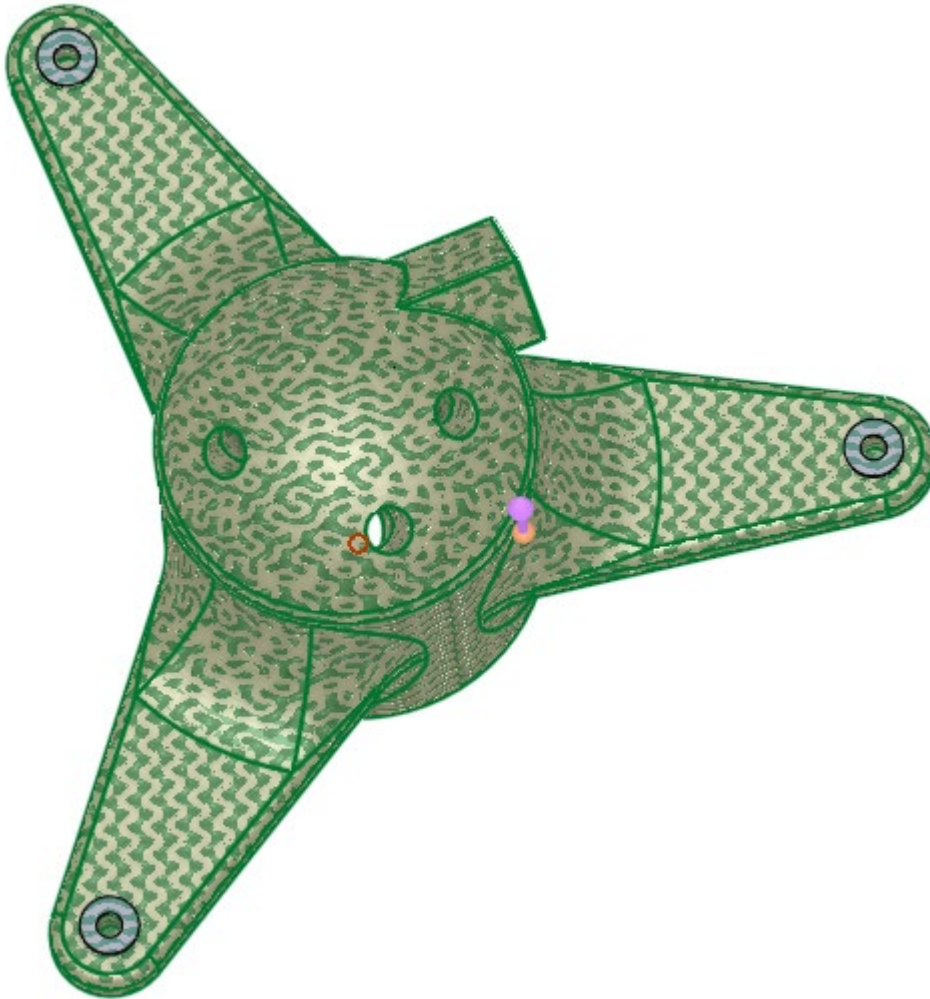
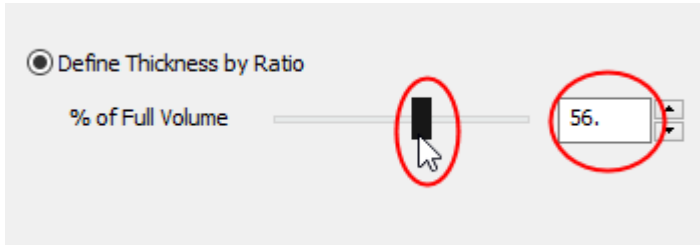
Thickness

☒ Define Thickness by Ratio

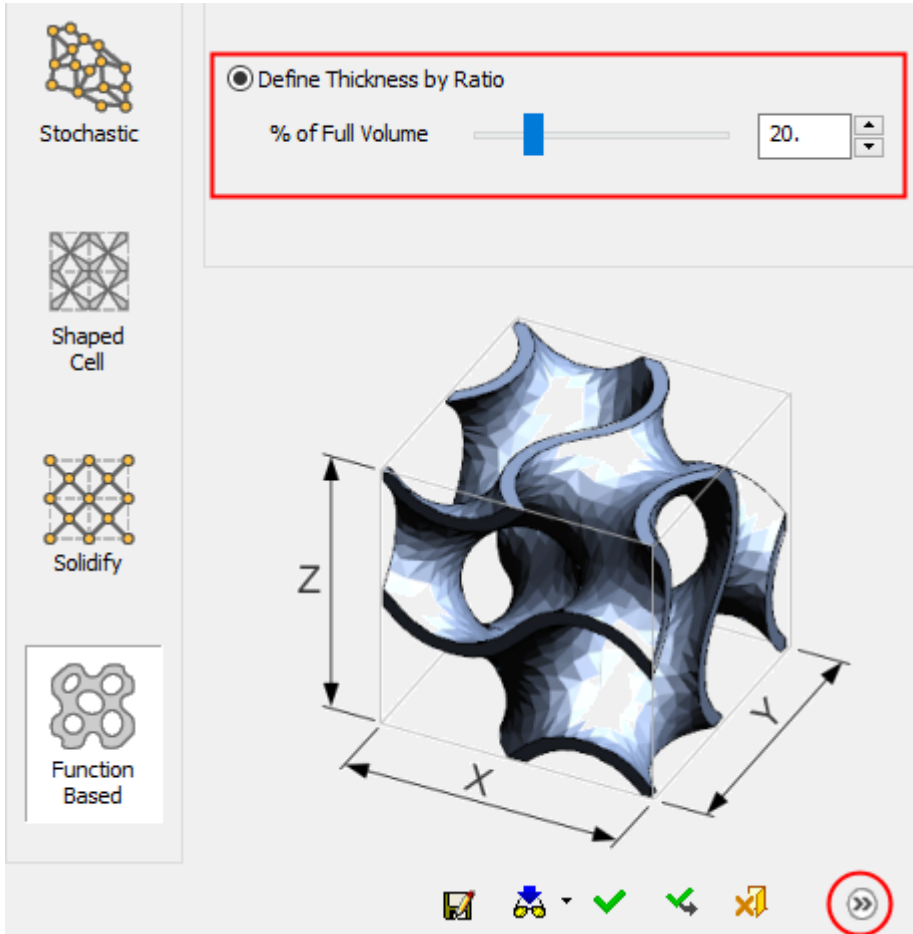
% of Full Volume



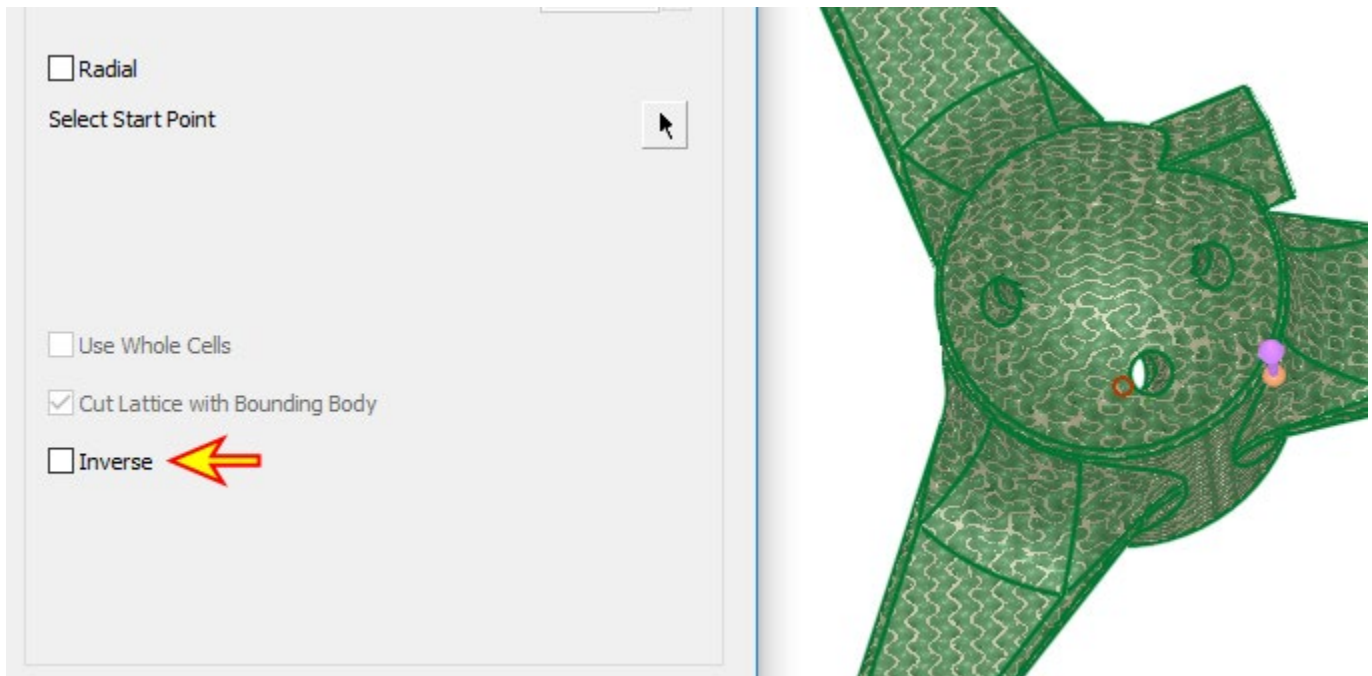
25. Change the ratio to **56** and see the impact on the lattice thickness.



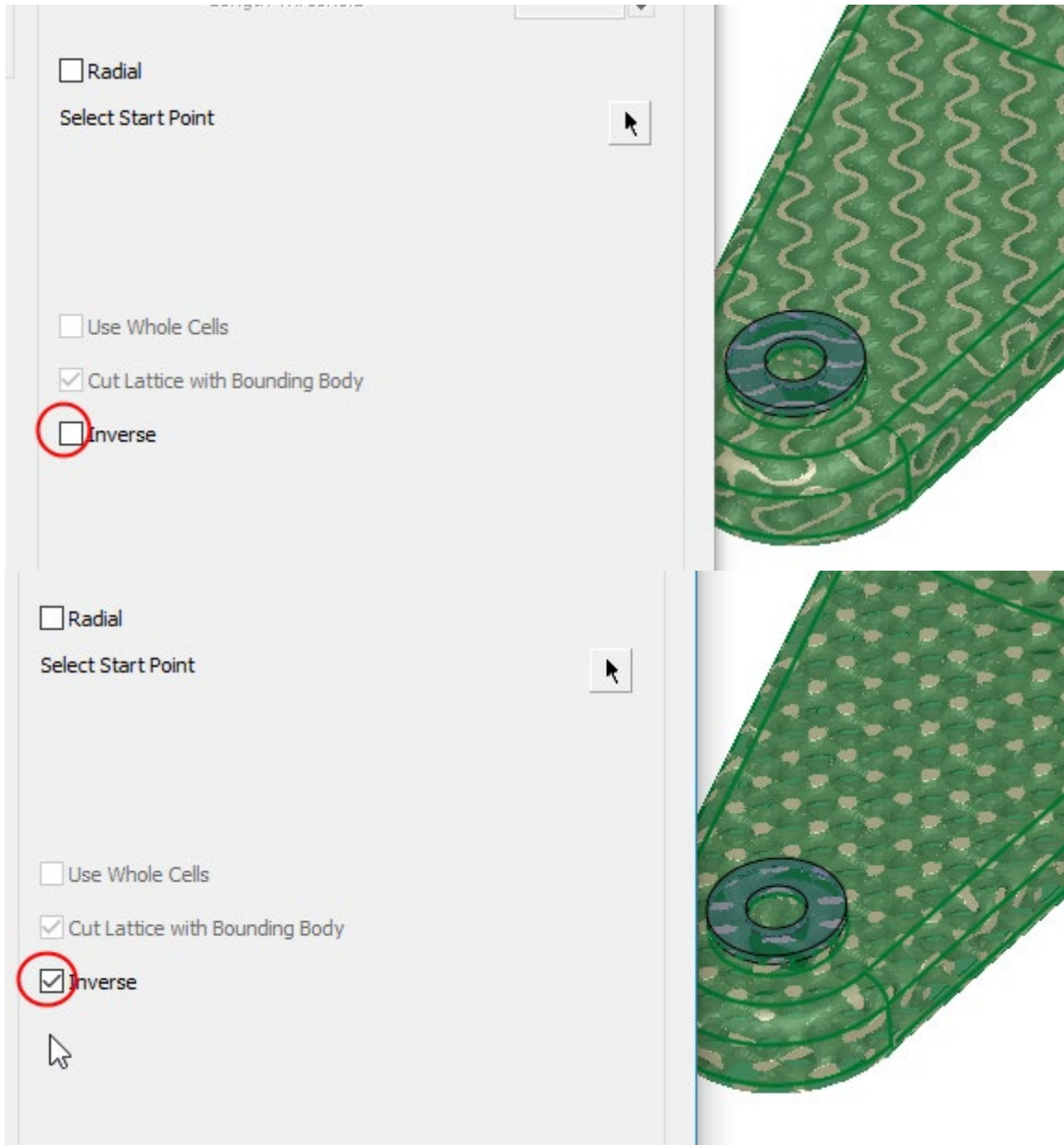
26. Set the ratio back to **20** and expand the dialog.



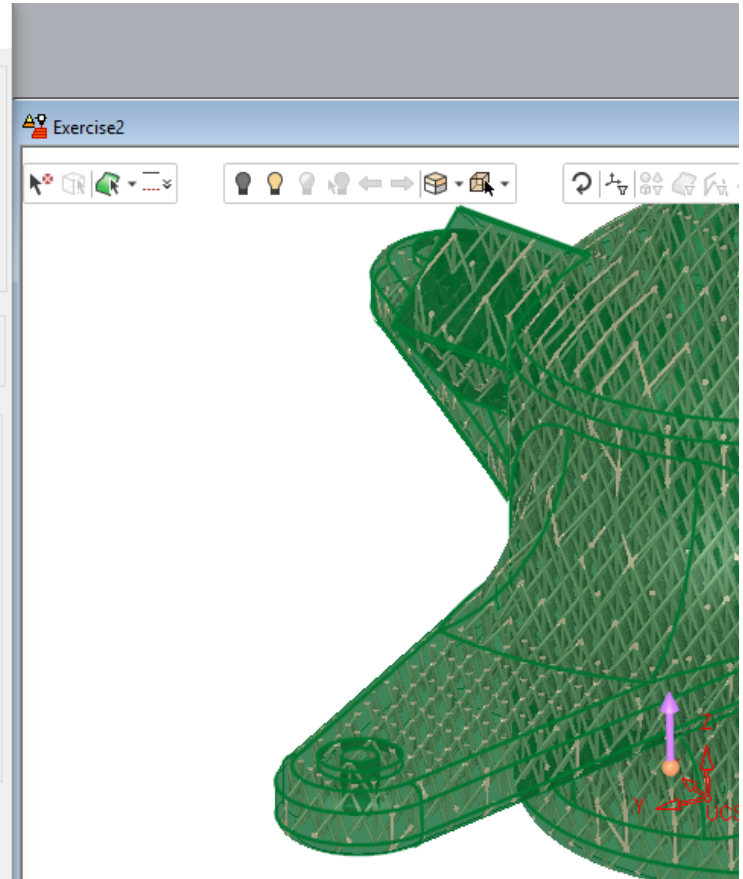
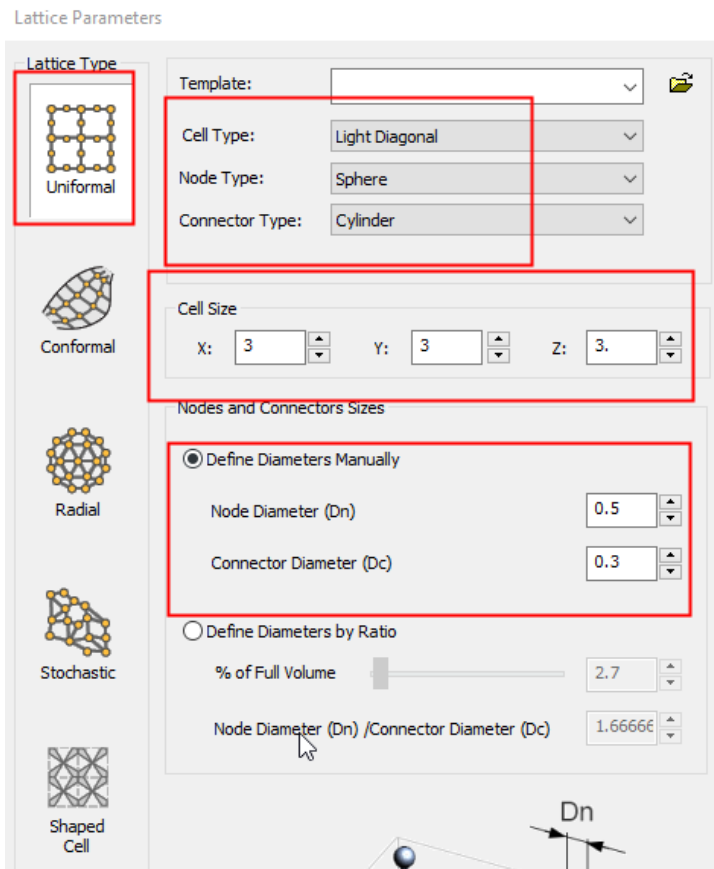
27. Notice the Inverse check box. When this checkbox is ON, the lattice is inverted; so that where there was material before, there will be no material now and vice versa.



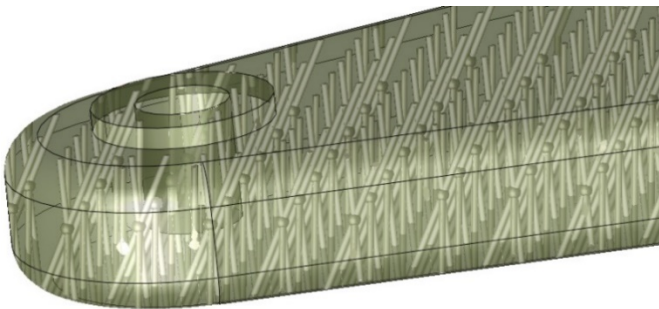
28. Compare the two results; when Inverse is checked ON and OFF.



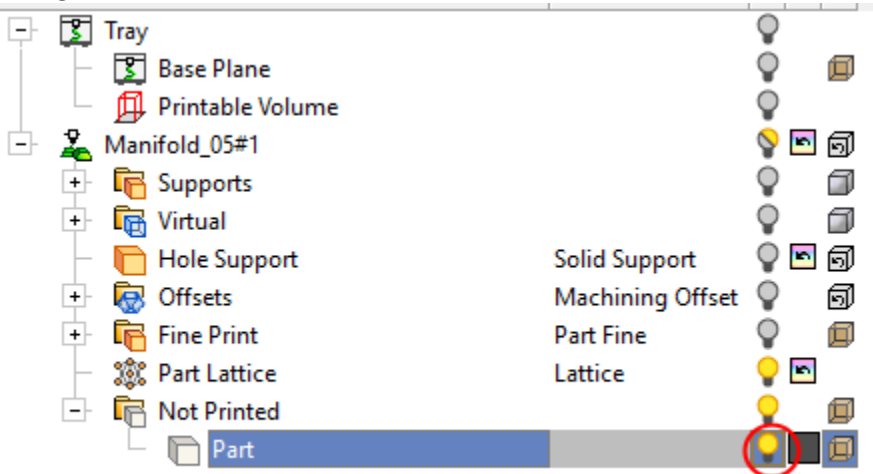
29. Select the **Uniform** Lattice Type



30. Press **OK** (on the Feature Guide).

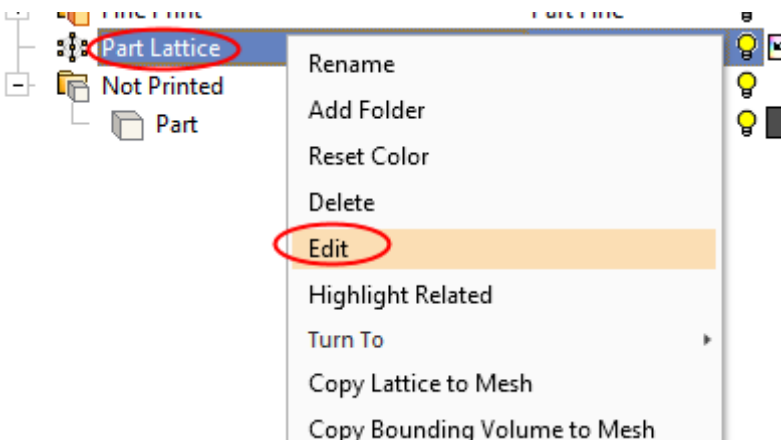


Note that the whole part volume has been replaced by the lattice structure. The new lattice feature was added to the tree. The part is automatically moved to a **Not Printed** leaf on the tree and is hidden, you can show it again by clicking the bulb on the tree.



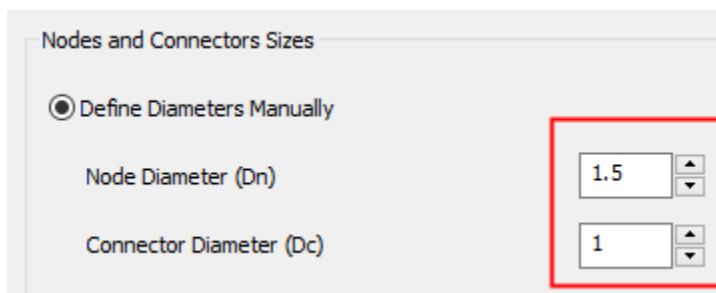
This is not how we wish to print the part; later on we will add a shell. But first let's edit the lattice.

31. Zoom in on the part – this lattice is very thin. Right mouse click the Lattice object and press **Edit**.



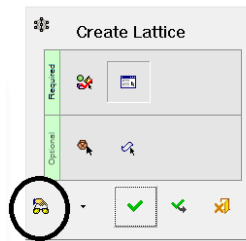
In the dialog, see that the current Cell size is dictated in **Define Diameters Manually** mode.

32. Make it thicker by changing the parameters so that the **Node Diameter** = 1.5 and the **Connector Diameter** = 1.

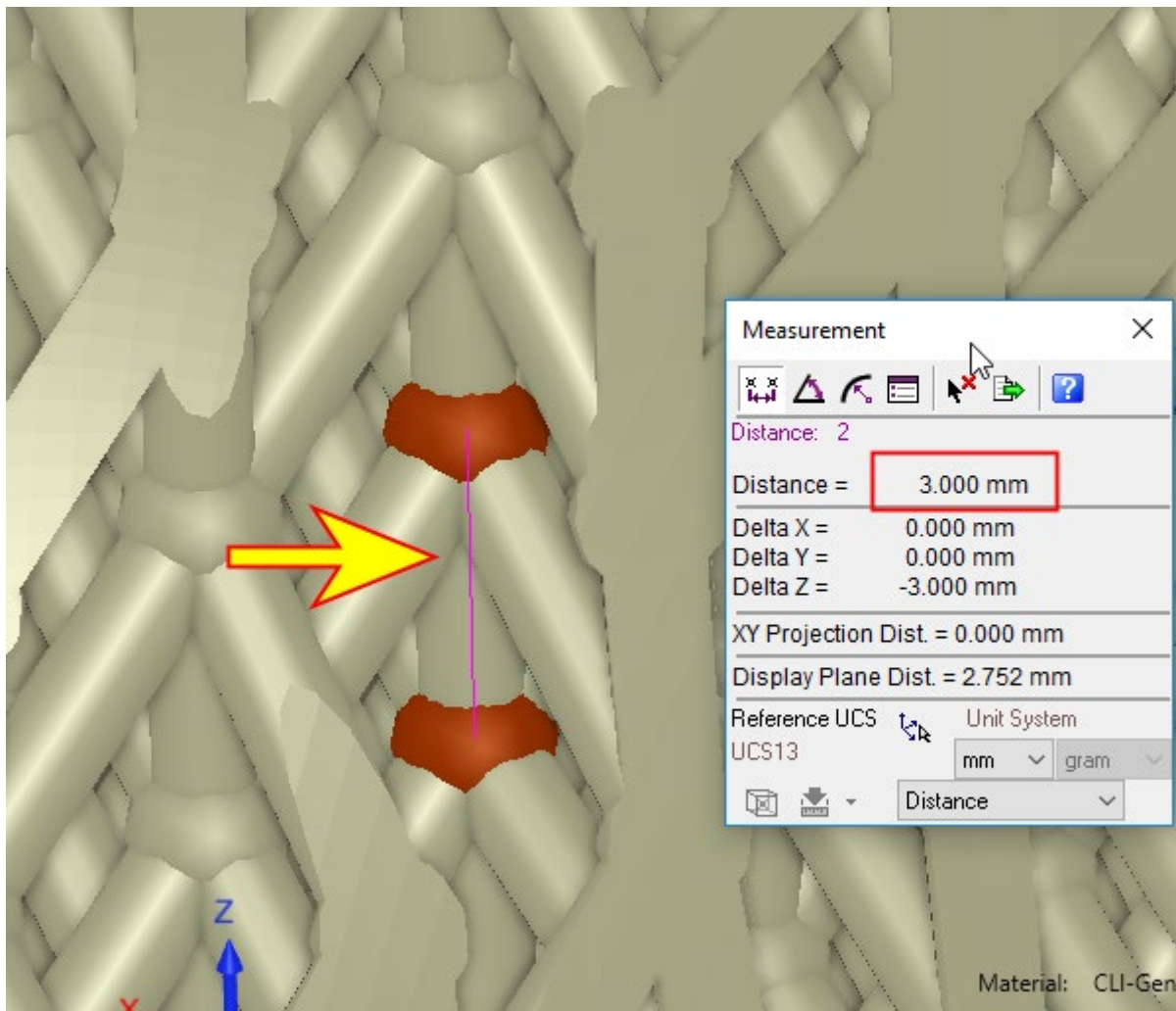


33. Right mouse click and click the Preview button

You can also switch from Manual Preview to Auto Preview for dynamic preview of the lattice.



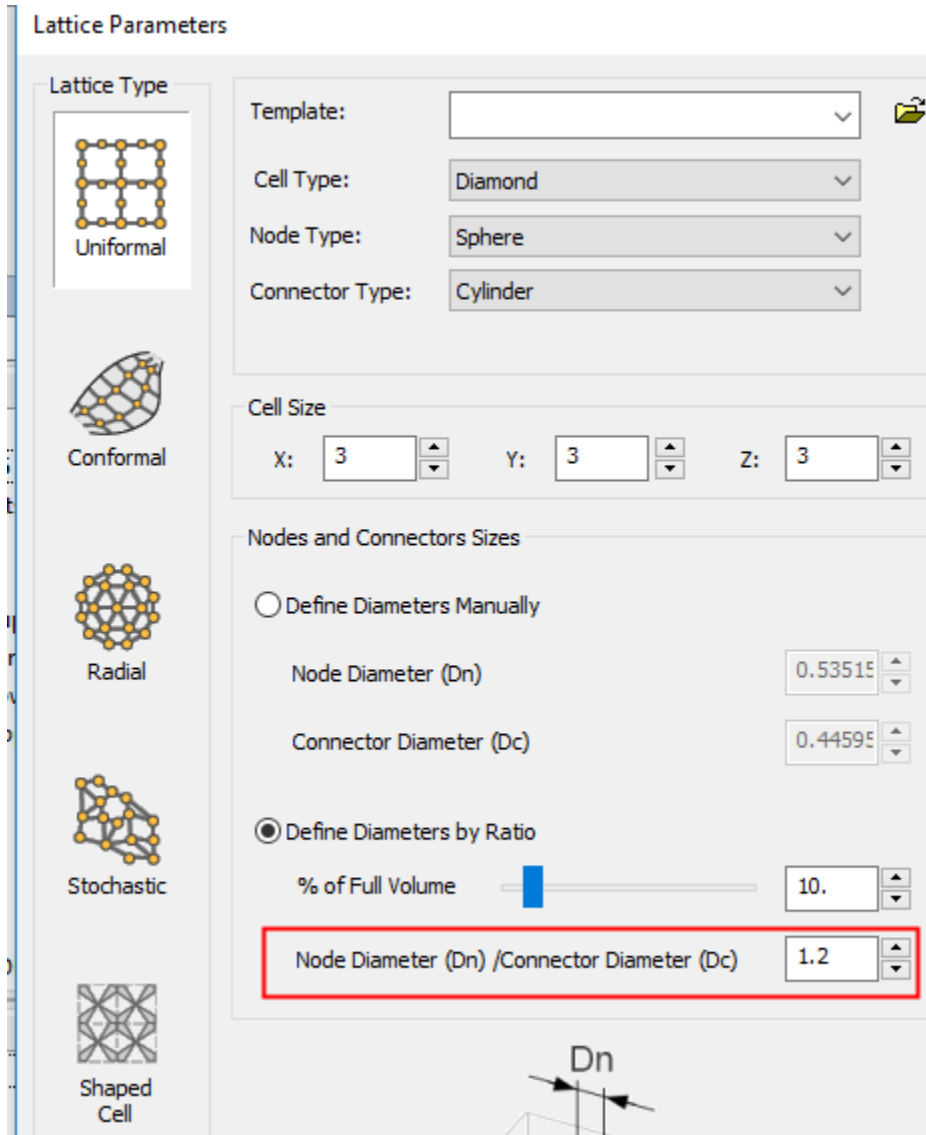
The distance between the cell nodes is set based on the defined cell size (the image shows the distance between the adjacent nodes, 3mm in Z):



34. Still in the **Uniformal** Lattice type, select the **Diamond cell type**. Set the Cell Parameters Definition to **Define Diameters by Ratio**.

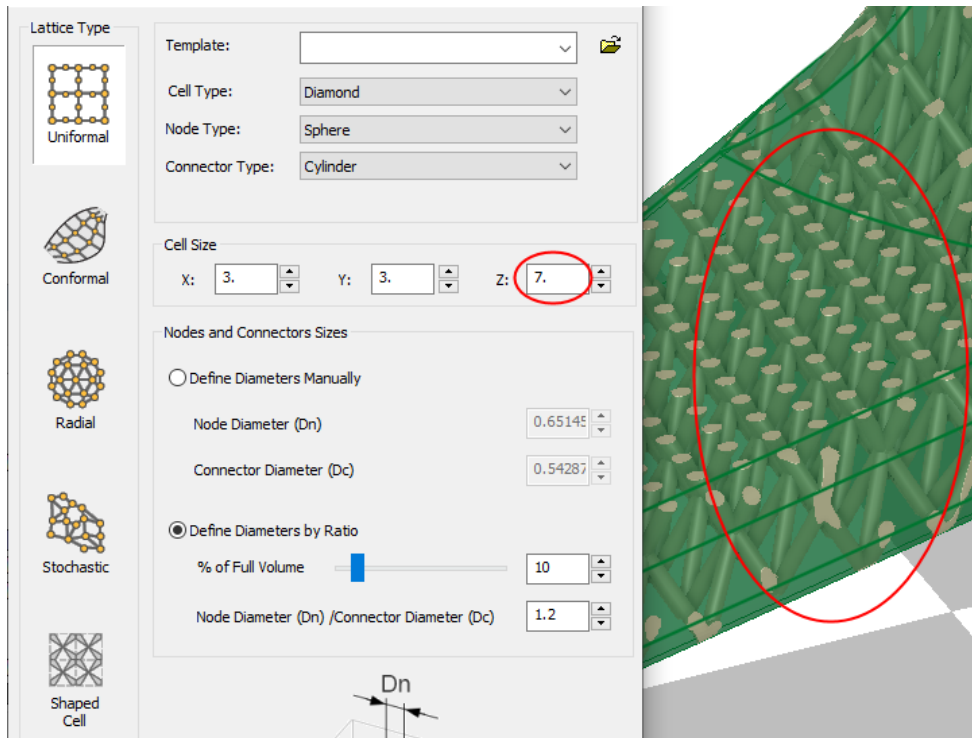
'Define Diameters by Ratio' - Define the diameters of connectors and nodes by a ratio between them, with their sizes defined by setting the percentage of the full volume that the volume of the lattice will consume.

35. Set the lattice volume as **10** percent and the node to connector ratio as **1.2**.

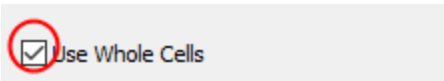


36. Change the size of the cell. Set the **Z value to 6.7**.

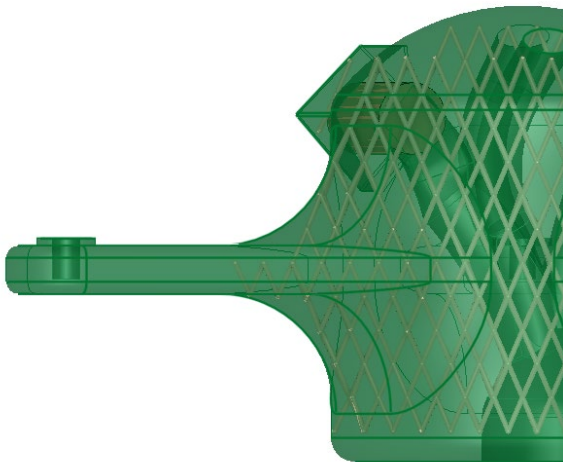
37. Rotate the part and zoom in on the wings, the lattice cell size is too big, whole cells cannot be created.



38. Expand the Lattice dialog, check the **Use Whole Cells** checkbox ON and press the **OK** button.




See the result; the system does not create the lattice where whole cells do not fit. Clearly, the cell size is too large.



When using Whole Cells, the system stops the lattice once there is no more room for additional complete cells.

39. Edit the Lattice again, uncheck **Use Whole Cells** and set the **Cell's X,Y,Z values to 5,5,4**, then press **OK**.







Template: 

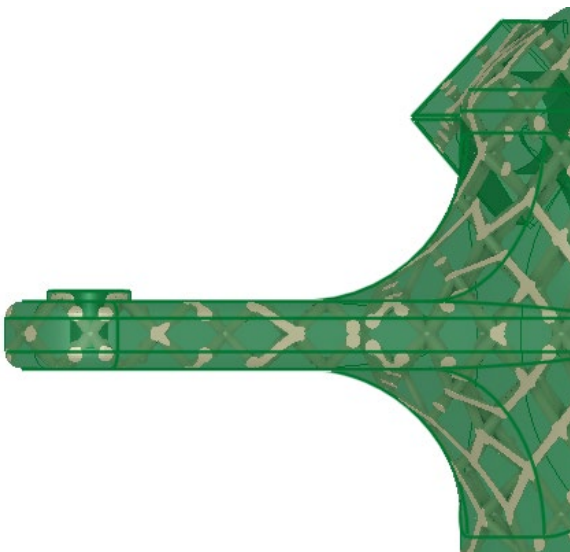
Cell Type:

Node Type:

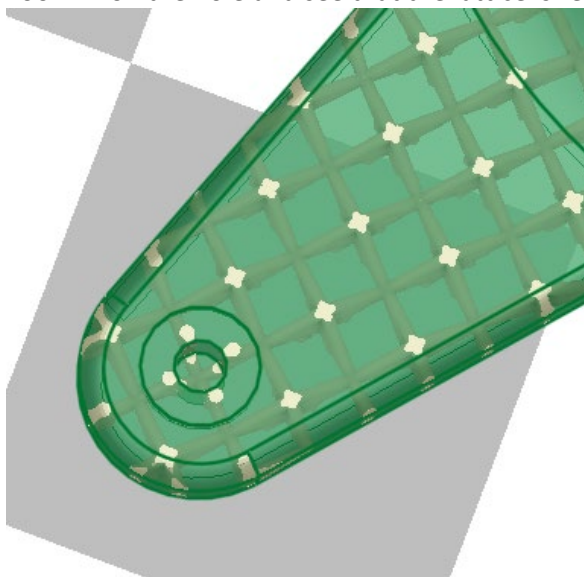
Connector Type:

Cell Size

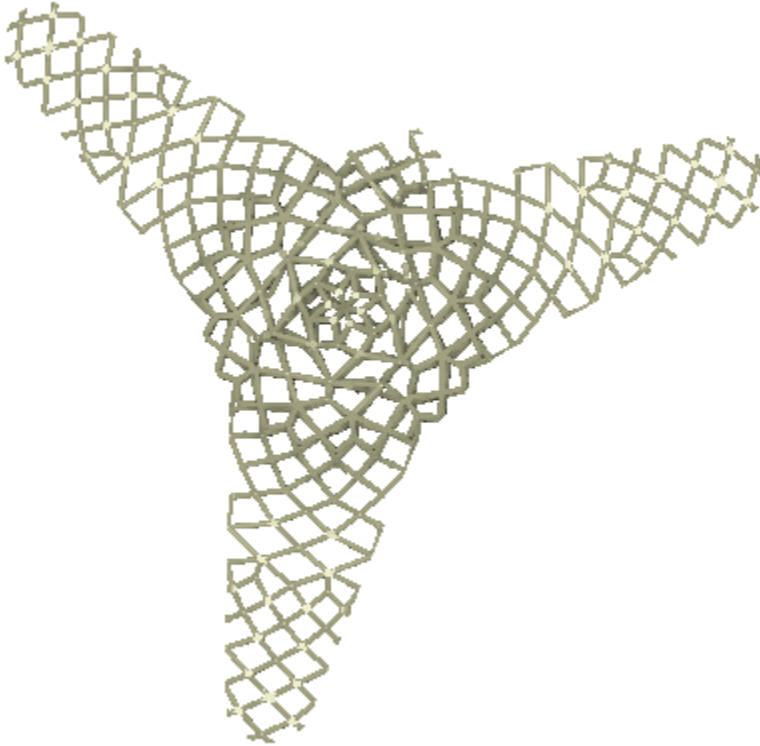
X:  
Y:  
Z:  



Zoom in on the hole and see that the lattice is reaching the edges of the hole.



40. Edit the Lattice Object again and switch from Uniform Lattice to **Radial Lattice**
41. Press **OK** to see the result.
42. Click the **Z axis** of the dynamic UCS to see from top view. The cell size changes according to the diameter of the part.



43. This view also manifests that the lattice is reaching the end of the object. There is no skin around the lattice and obviously, this is not what we want. Therefore, edit the lattice again and this time press on the Feature Guide the optional stage '**Define Shell**'



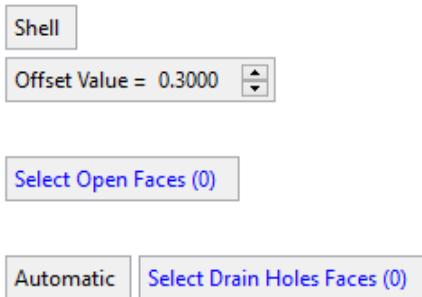
44. Set a shell value of **0.3 mm**.

Remember that we do need to let the powder out so you may need to define dedicated drain holes to let the powder out.

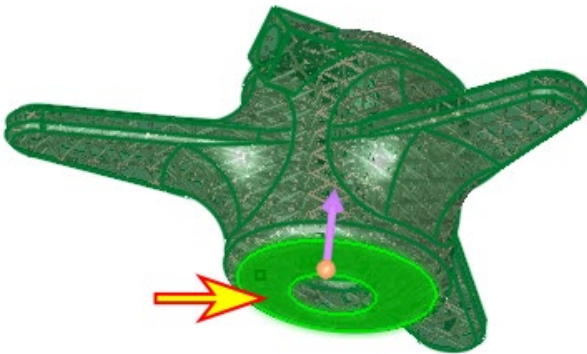
There are two options for draining the powder within the lattice creation feature:

- Open the part by defining an **open face** at the bottom.
- Adding **draining holes** along

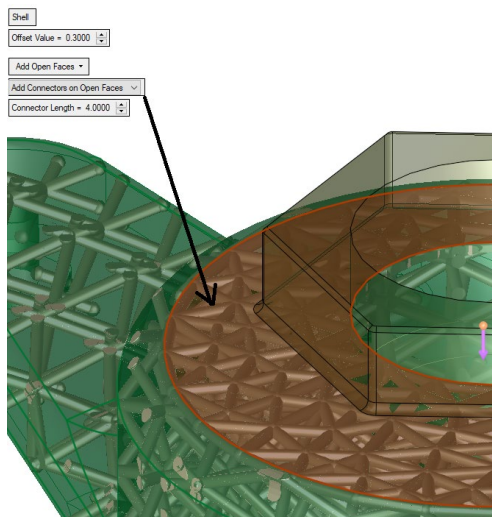
45. Keep 'Add Open Faces'

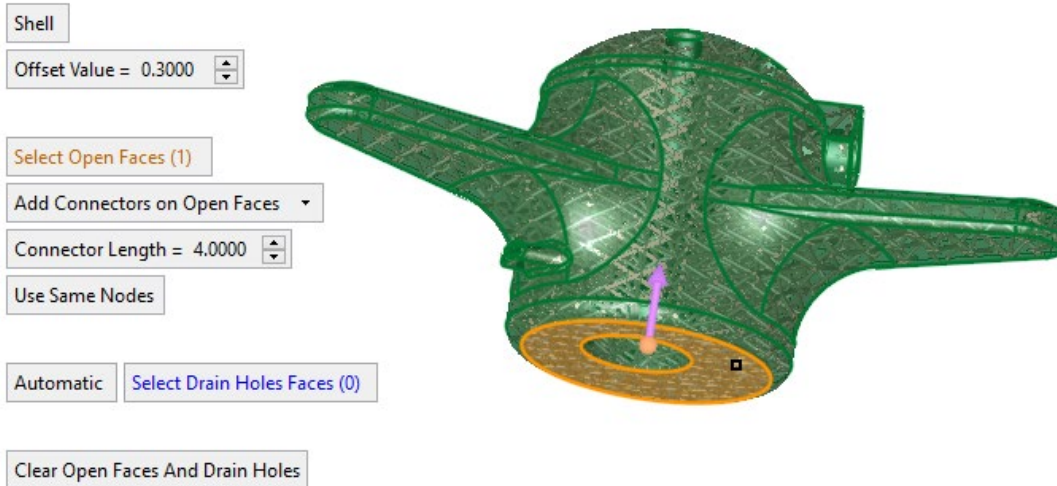


46. Press the tab **Select Open Face**, and select the face as indicated by the arrow in the picture below and Exit.

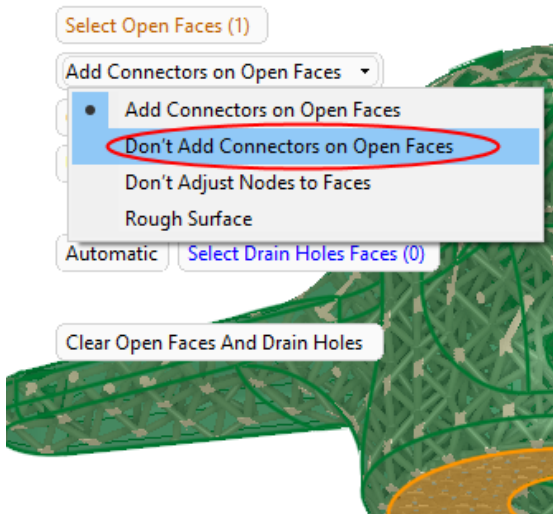


You can also create add connectors and define a different shape for the nodes on the selected open faces. This adds a connector between each set of nodes lying on the open area. The length of the connector can be set as well.





47. To determine the surface of the open faces, select an option from dropdown list. Select **Don't Add Connectors on Open Faces** to not add additional connectors between the nodes and adjust those nodes that are close to the face, by moving them up or down to be directly on the face.



48. When this option is selected, a toggle option is displayed to keep or remove all unsupported (lowest) elements from a lattice structure with a shell and open faces.

The **Keep Unsupported Elements** option keeps all unsupported (lowest) elements in a lattice structure with a shell and open faces, while the **Remove Unsupported Elements** removes all unsupported (lowest) elements from a lattice structure with a shell and open faces.

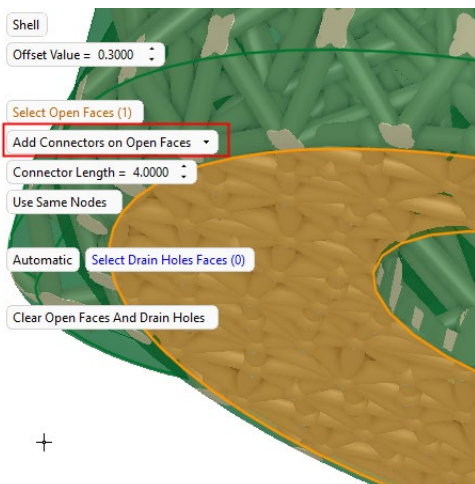
49. Toggle between these two options and see the different results.



50. Accept the default option **Keep Unsupported Elements**.

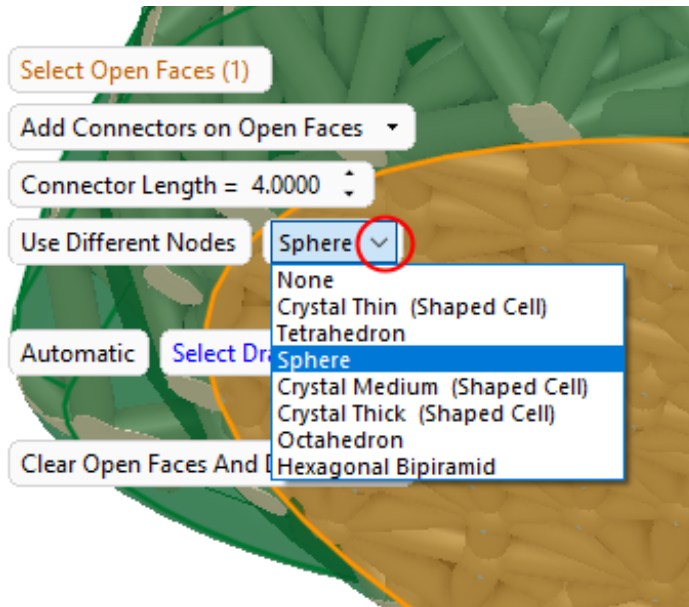
51. Examine the result of Add additional connectors between the nodes to display a nice grid over the open face. The **Connector Length** parameter allows control over the tightness of that grid.

Default = 5 mm.



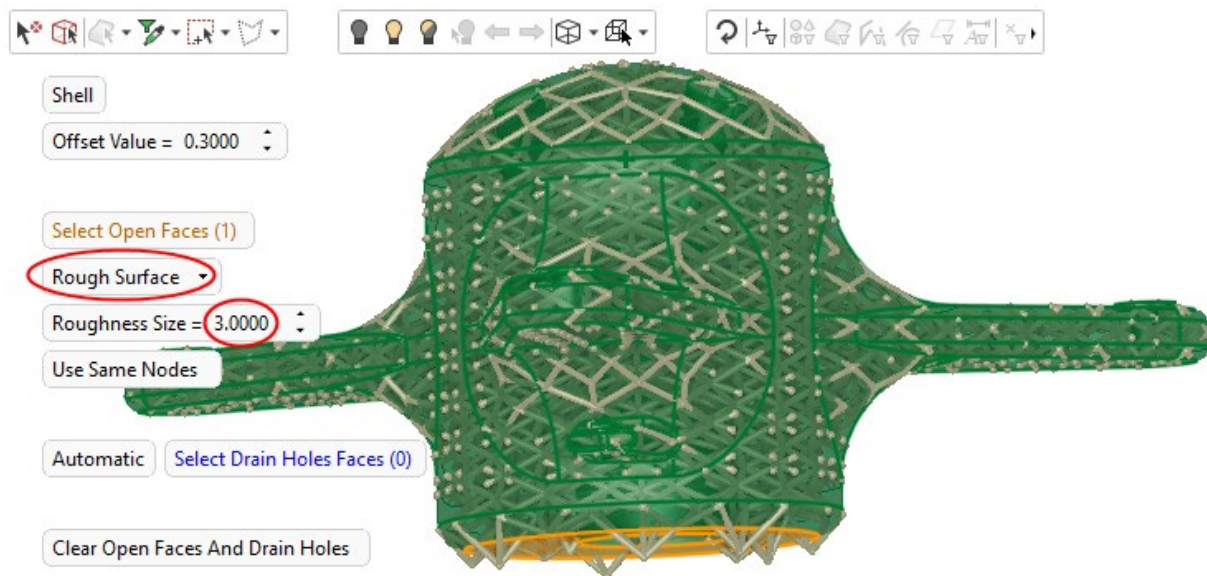
The outer nodes in the selected open face areas can have a different shape than the other nodes, by selecting a node shape from a dropdown list. This is a toggle option **Use Same Nodes / Use Different Nodes**.

52. Select the Use Different Nodes option and try other node types.

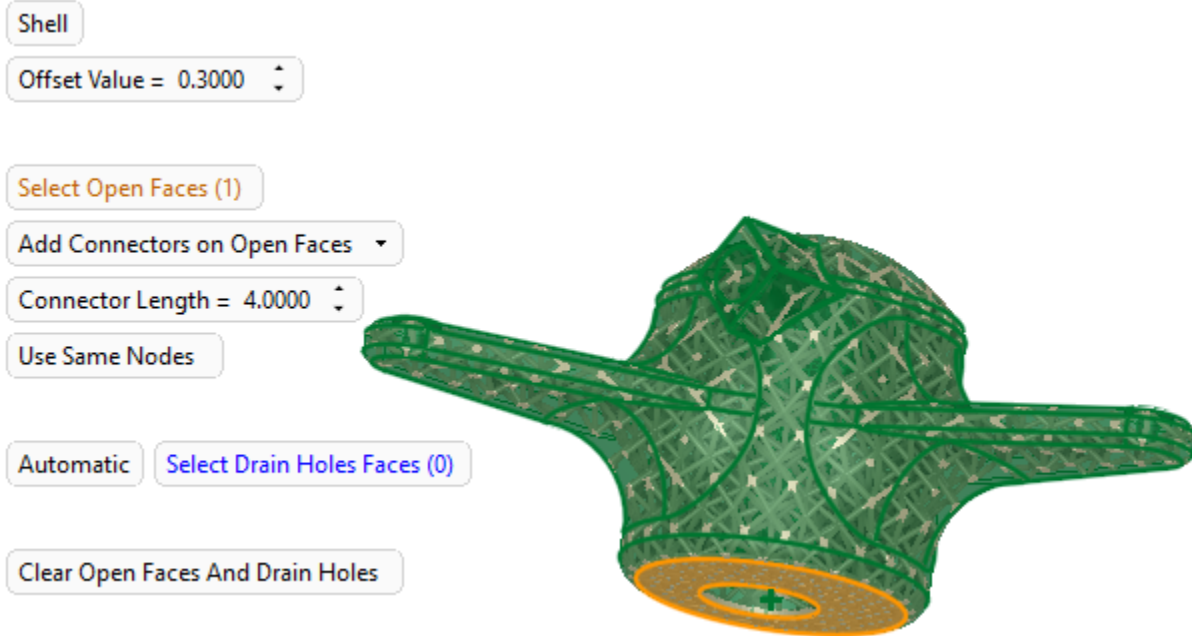


53. Select the **Rough Surface** option. Set the **Roughness Size** to 3.

The Rough Surface option moves nodes randomly up and down along the face to make it rougher. This may be a requirement for medical use where bone structures may more easily adapt and grow into the implant. A **Roughness Size** parameter defines the size of the protruding or sunken nodes. The images below show an exaggerated state with high roughness to illustrate the effect.

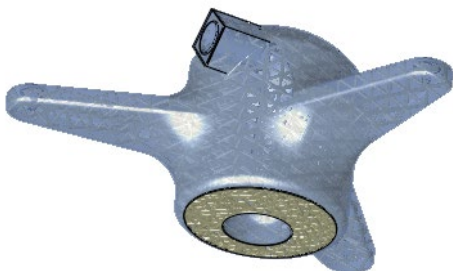
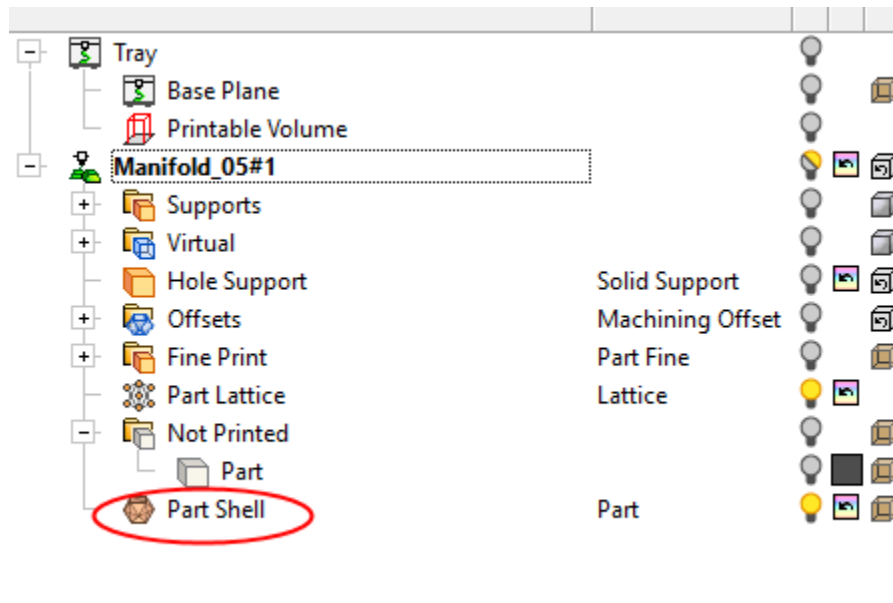


Change back to the default parameters.



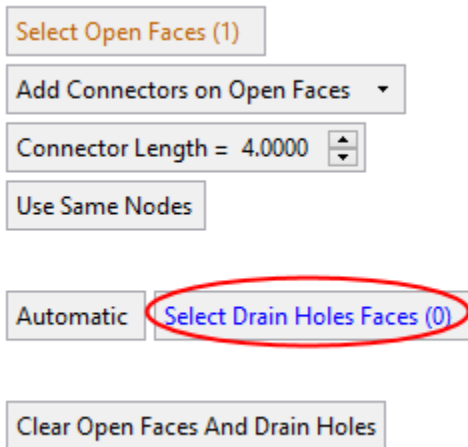
54. Press **OK**.

The result is a mesh shell body around the lattice. To see them together, make sure that the new shell object and lattice are shown

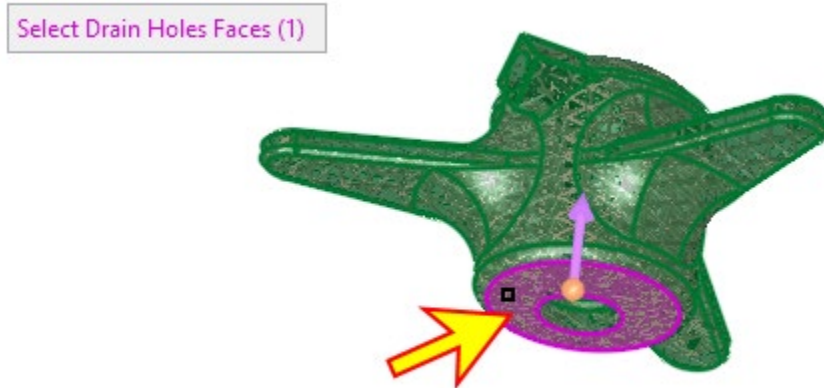


55. Edit the Lattice again.

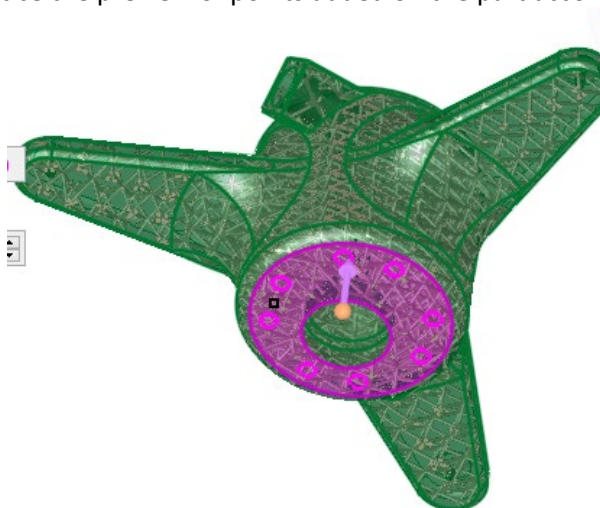
56. Click the optional button for Shell and Click the 'Add Drain Holes Faces'.



57. Pick the bottom face of the part, and Exit (MMB).

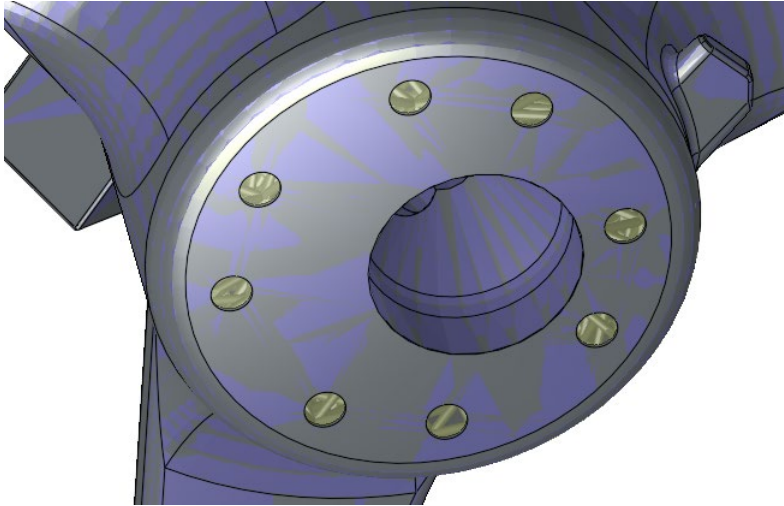


Notice the preview of points added on the part according to the spacing value.



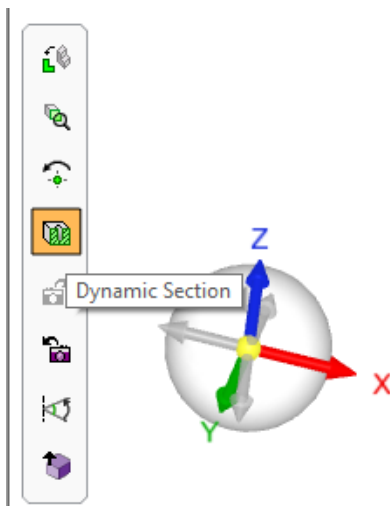
If you wish, you can switch from Automatic to Manual and add some more points, or pick specific existing points to delete them.

58. Press **OK**.

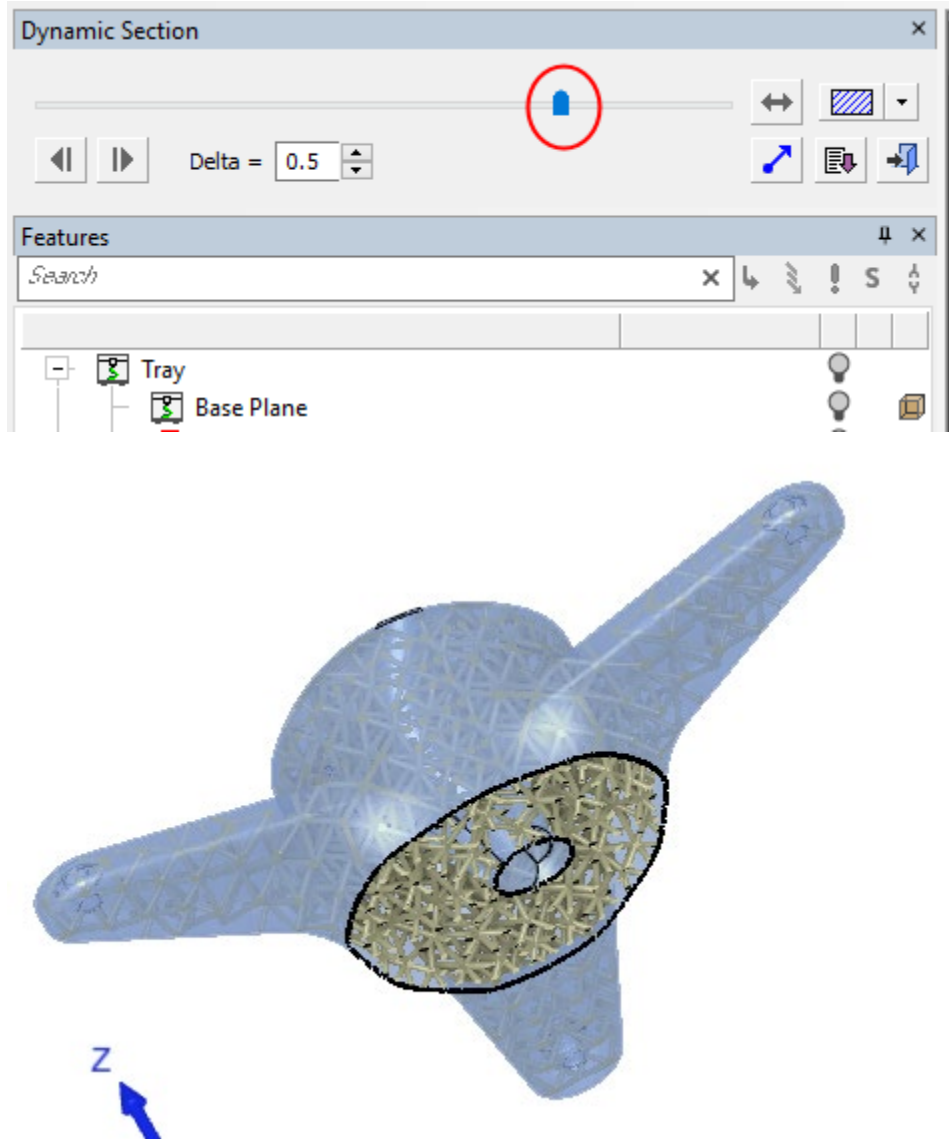


59. Hover with the mouse over the area of the dynamic UCS to get the display bar.

60. Click Dynamic Section. Click somewhere along the cap and zoom in.



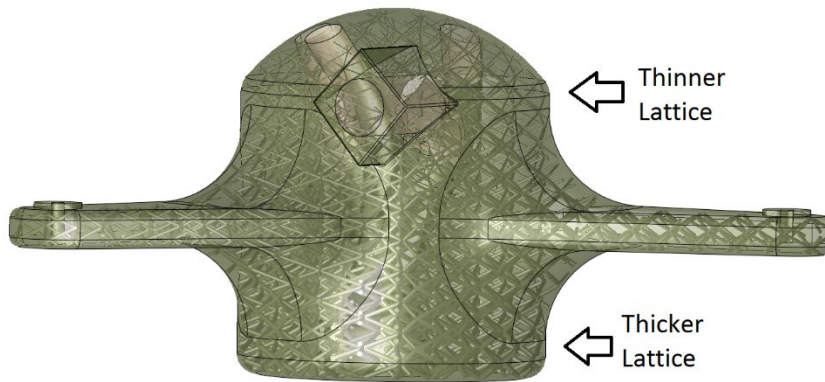
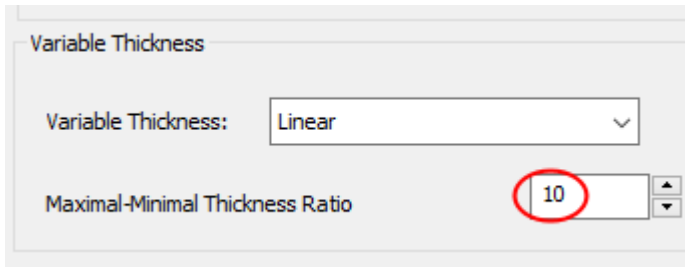
As you can see, the shell wraps around the lattice. You can move the dynamic section back and forth by moving the bar.



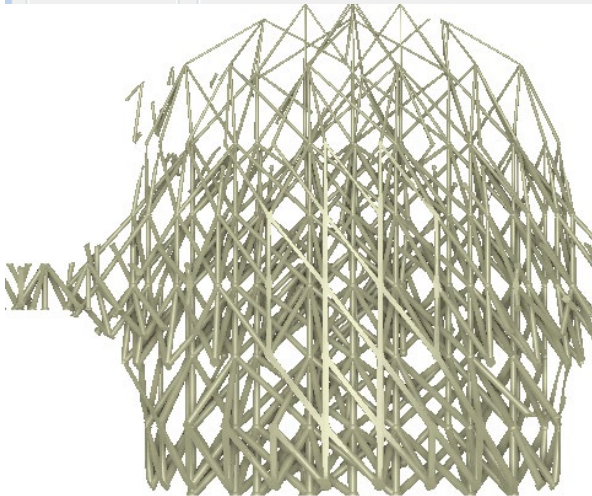
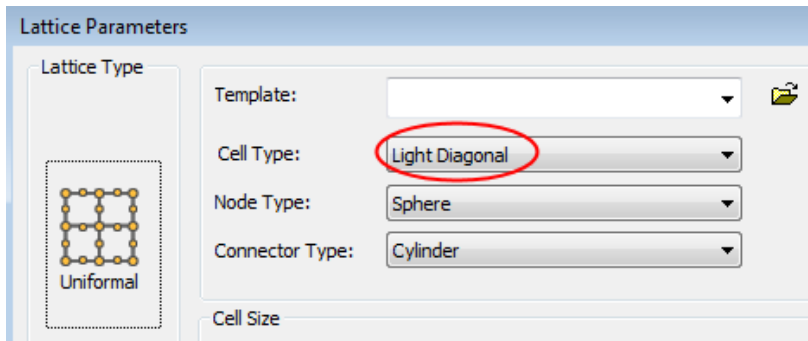
61. Exit Dynamic Section.

62. **Edit** the **Lattice** again. The structure we have created here had the same thickness for each of the connectors of the lattice. However, it may be that a thicker lattice may be required, for example, at the bottom of the part or on any other area that will be subjected to more strains during the operating life of the part. For that, use Variable Lattice.

63. Expand the dialog. Check the **Linear** option, keep the **Maximal-Minimal Thickness Ratio** as **10** and press **preview**.



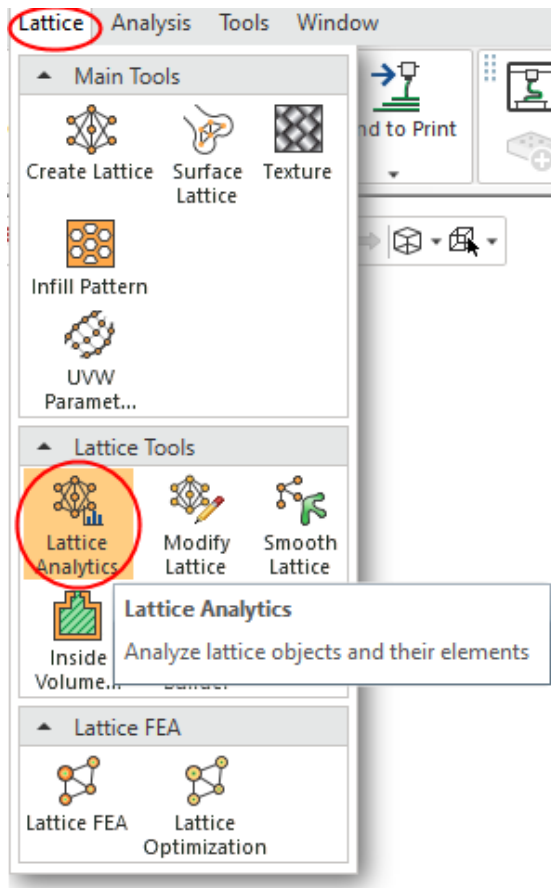
64. Set Cell Type to Light Diagonals – to see the difference best.



65. Save the file.

Part 2 – Lattice Information

66. Select the Lattice Analytics option from the menu.

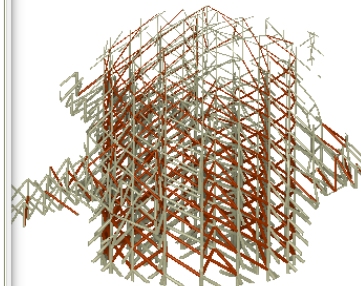
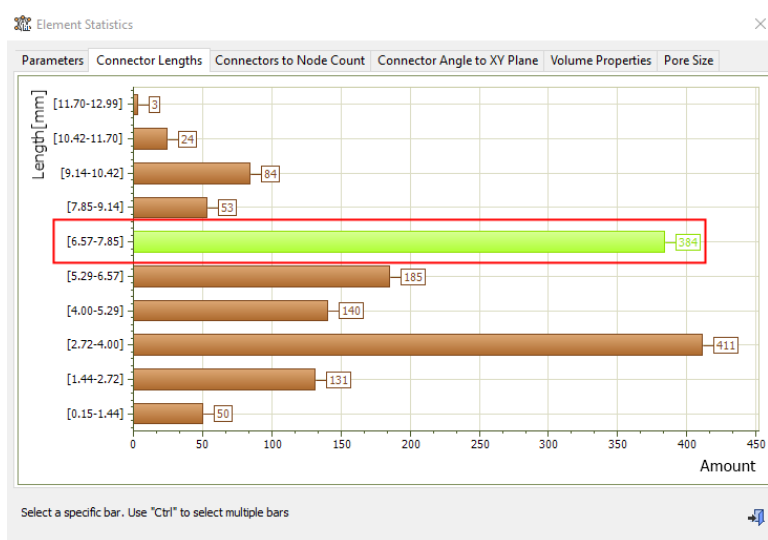


67. Select the Lattice,
68. A dialog shows up with Parameters, Connector lengths, Lattice Volume, Porosity Value, etc.
69. Click the Connector Length tab

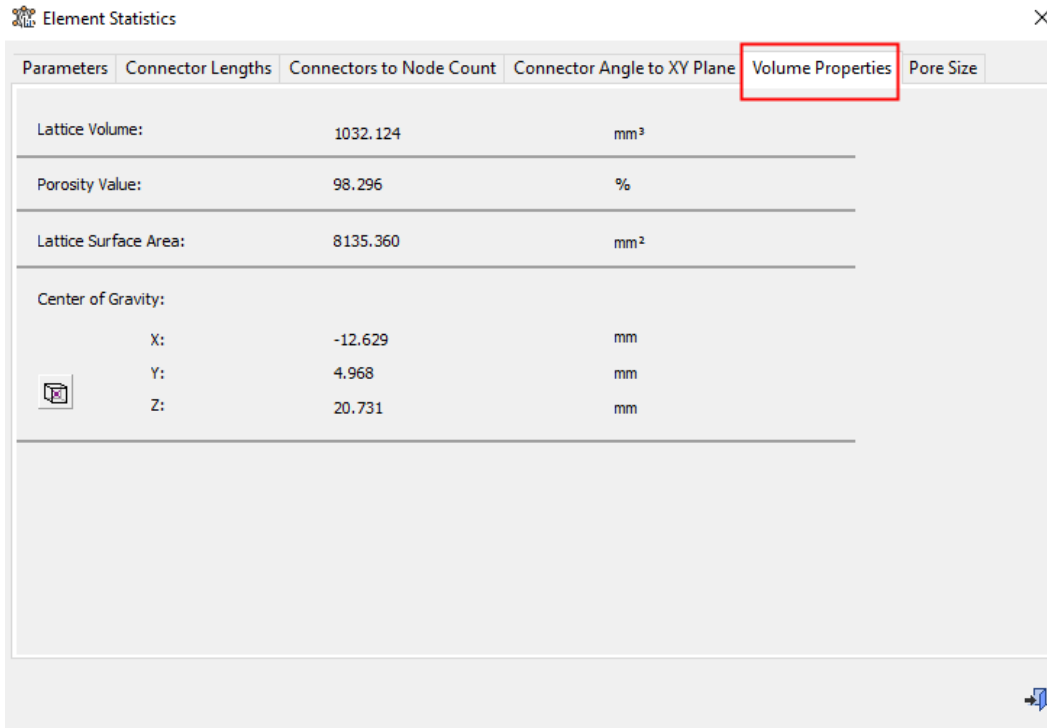
Element Statistics

PARAMETER	VALUE
Long & Low Angle	221
Require Supports	0
Outer Nodes	656
Open Face Nodes	0
Lumps	26
Nodes	939
Connectors	1465

70. Pick any of the items on the diagram to highlight the relevant lattice data on screen.



71. Press the Volume property tab to see the lattice Volume, porosity value, surface area and center of gravity:



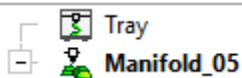
72. Exit the dialog

73. Save the file.

Part 3 – Lattice Update

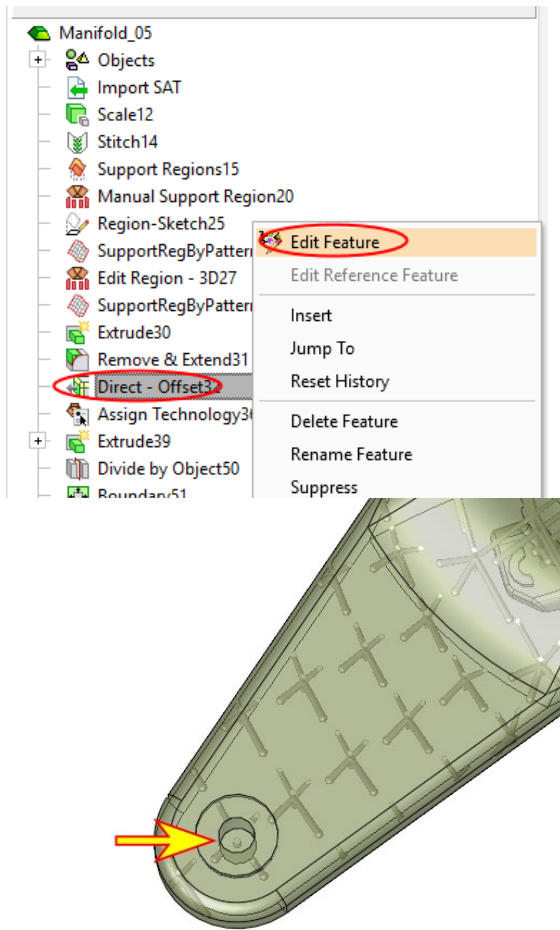
The lattice structure you have created is fully parametric. Any change in the design will lead to lattice regeneration, based on the updated model. Let's edit the size of the bushings, to add more thickness.

74. Activate the part (double click Manifold_05) on the tree.

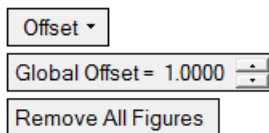


We want to change the offset we did in the feature **Direct – OffsetXX** (the suffix stands for the number of the feature on the tree, this may vary depending on the actual work done in the part).

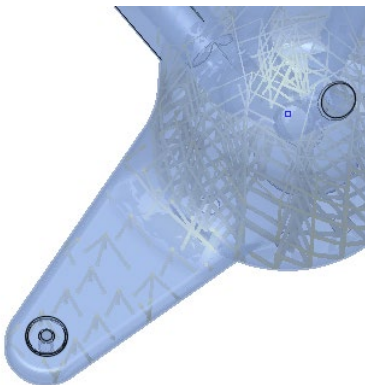
75. Right mouse click the feature **Direct-Offset** (the one after the **Remove & Extend** feature) and from the submenu select **Edit Feature**



76. Change **0.5** to **1.0** and press **OK**.

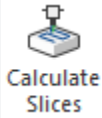


See that the lattice has been updated and now reaches the new edges of the hole.

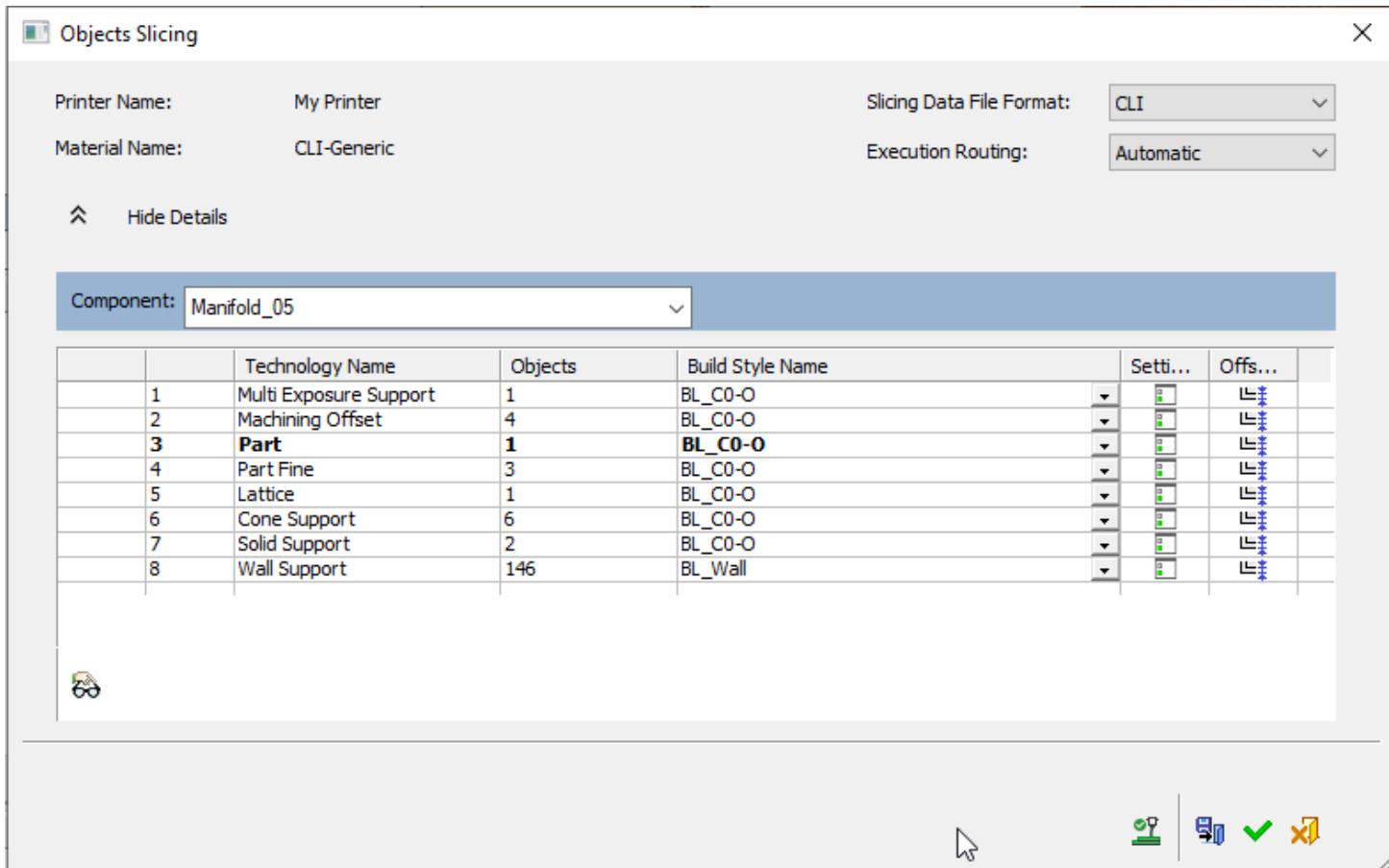


Part 4 – Slicing

77. From the Tool Bar click **Calculate Slices**



The Slicing dialog shows the Technologies we have assigned for this part, how many objects we have for each Technology and the Build Style that is attached to each Technology.



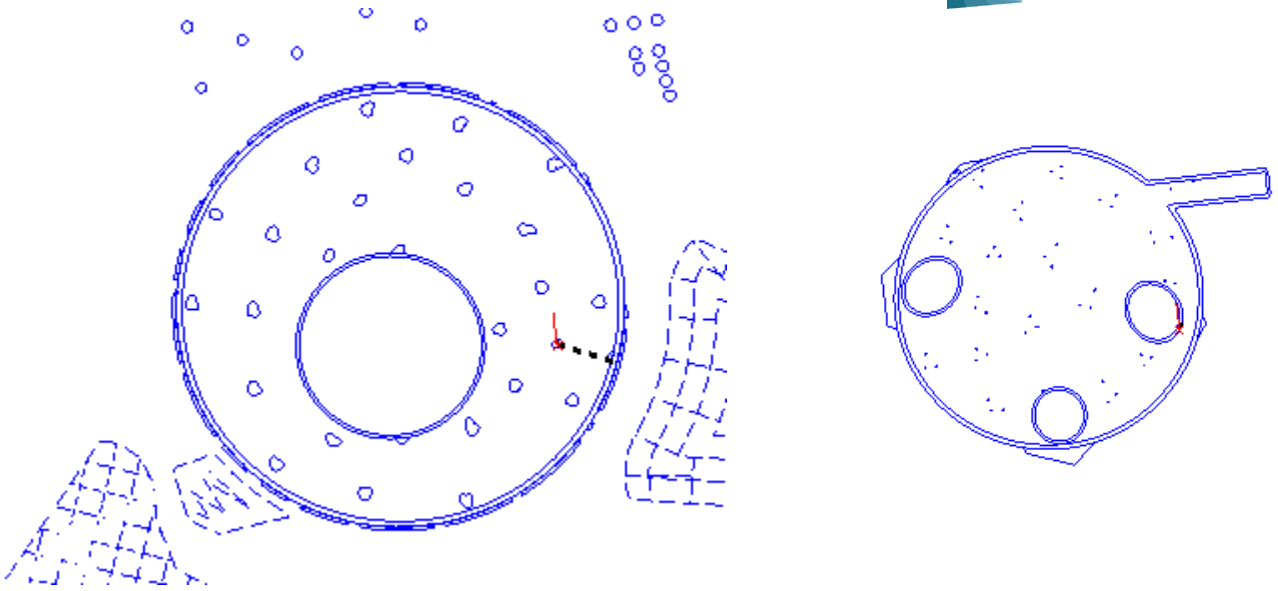
78. Press **OK** to calculate. This may take a few minutes.



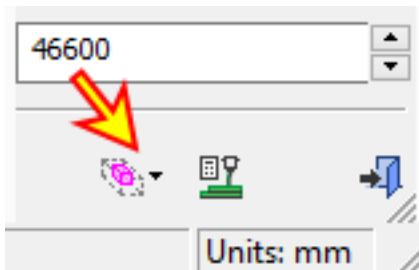
79. After calculation is over, from the toolbar press the Slice Viewer.

You can now go through all the slices by moving the slide bar.

As you move up, the lattice starts building up. As you move the slider up, you will notice the slicer areas in the lattice get thinner, up to around layer 470.



80. To see only the hatch patterns in each layer, hide the parts using the display button at the bottom of the navigation bar.



End of Exercise.