



The Basics of Growing 3D Models

This article covers the basic requirements that need to be met in order to “grow” your 3D model. Each machine used to grow your 3D model has different capabilities, resulting in different tolerances, surface finishes, strengths, and colors. The key to successfully growing any part starts at first saving the model in the correct format and then ensuring that it is a “watertight” 3D model. Creating a watertight 3D model in the correct or “standard” format means that the following must be met:

1. Saving your model in the standard file format
2. The model has sufficient volume
3. The model does not have any holes
4. There are no overlapping and/or intersecting surfaces
5. Colors are applied to each facet on a surface rather than just “Texturing”
6. The model contains one solid object

These requirements will allow the majority of models to be grown successfully.

Saving Your Model in the Standard File Format

To better understand why your model may not be watertight even though it looks like one complete solid in the computer, you first must know more about the standard file format used for growing parts. The standard file format for growing 3D models is a .STL which stands for stereo lithography, not to be confused with the industry abbreviation SLA (stereo lithography apparatus). This file format represents a part by sectioning surfaces into many different triangles.

Because of these triangular facets, a curved surface can never be perfectly represented. In order to best represent a curved surface, the size of the facets need to be adjusted so that there are enough and the model doesn't have jagged edges as depicted in figure 2.

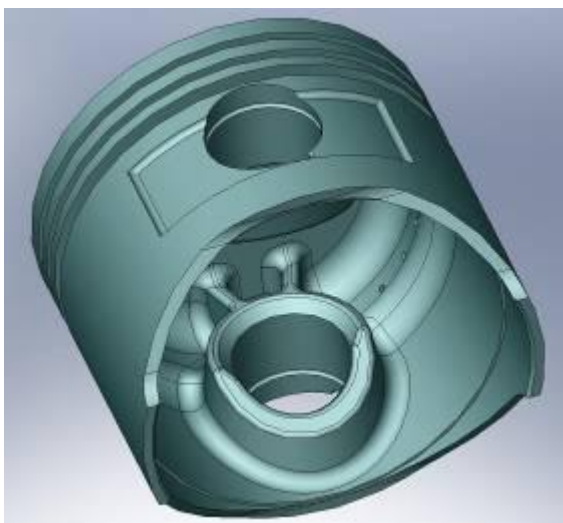


Figure 1, Original piston model.

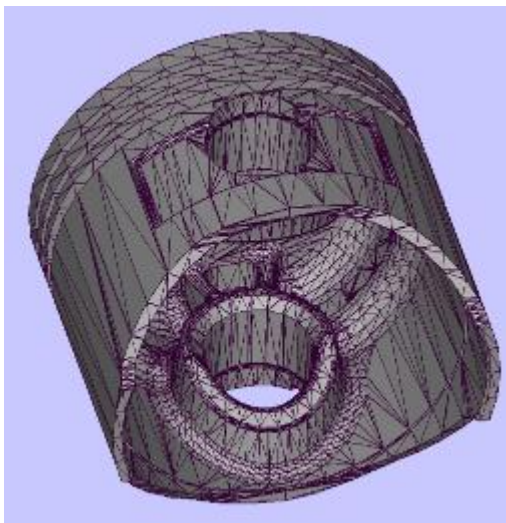


Figure 2, STL format of piston model with jagged edges.

On the other hand, facets can be created too small, shown in figure 4, resulting in a file size that is too large and in turn causing computer problems. Figure 3 shows a model with enough facets to grow a good part, while keeping the file size small enough that the computer can handle it. A good rule of thumb for the file size is that if it is over 15-20 MB, the facets are probably too small.

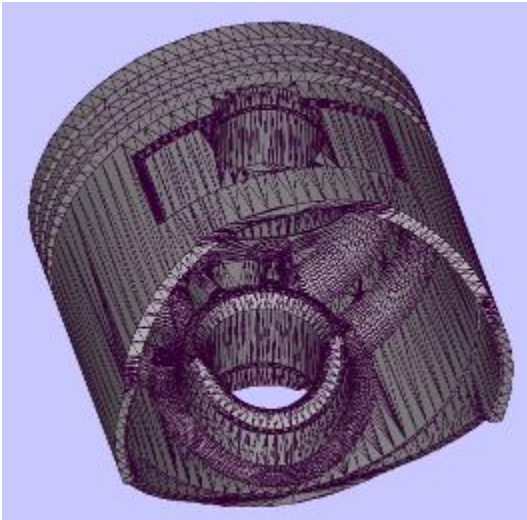


Figure 3, STL with proper sizing of facets.

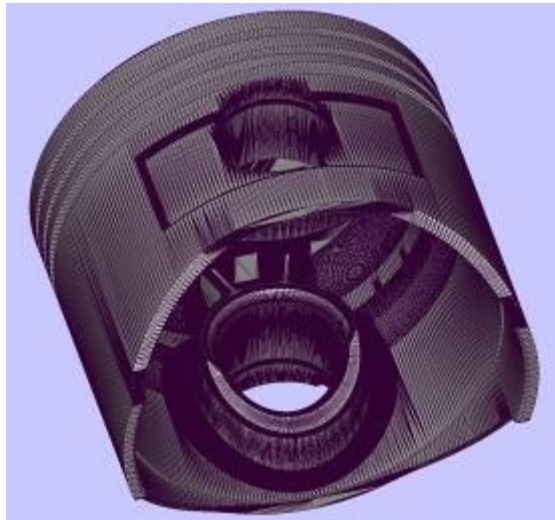


Figure 4, STL with too many facets.

Exceptions to this rule are files with tremendous detail, like that of the gargoyle in Figure 5 & 6, please consult with us if you have a file that you feel needs to be larger than 15-20 MB, or if you are not sure how to adjust the size of the facets.



Figure 5, Computer file of gargoyle.



Figure 6, Grown gargoyle.

The Model has Sufficient Volume

If the 3D model is made up of faces and planes that are not connected, then the system growing it will try to create infinitely thin walls that will fall apart. Volume is a good indicator of whether or not your model is truly “watertight”. As you can see from figure 7, the model looks ok, but there is an error, highlighted in yellow, causing the computer to see only a small amount of volume, it is interpreting it as having infinitely thin walls. In figure 8, the error has been corrected and the volume has risen to a reasonable amount.

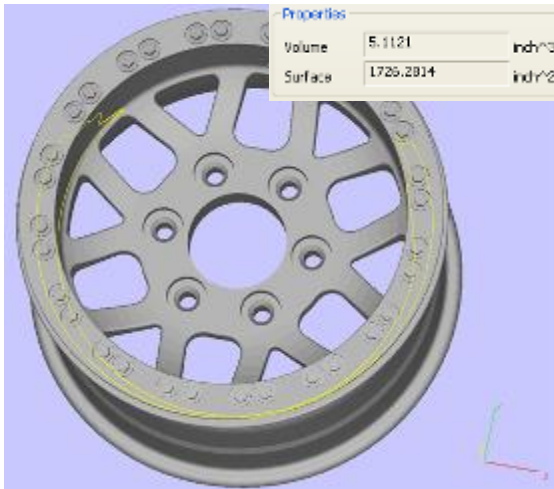


Figure 7, Part with error, causing the volume to be incorrect.

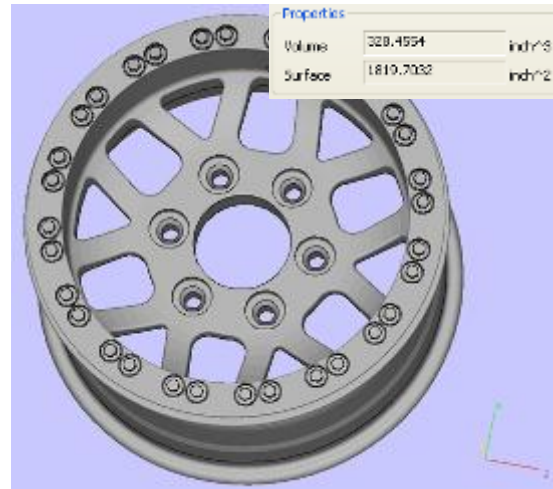


Figure 8, Corrected part with accurate volume.

Imagine trying to build a large structure out of thin sheets of paper; it would not work. For an object to support its own weight, it has to have a substantial amount of volume so that it will not collapse. A good rule of thumb for wall thickness is .05 inches (1.5 mm). This will vary depending on the application, material and system being used. If there is a large object with substantial weight that is being supported by this wall, you may want to thicken it up more, much like the example below in figure 9 & 10, of a rooster with thin legs.

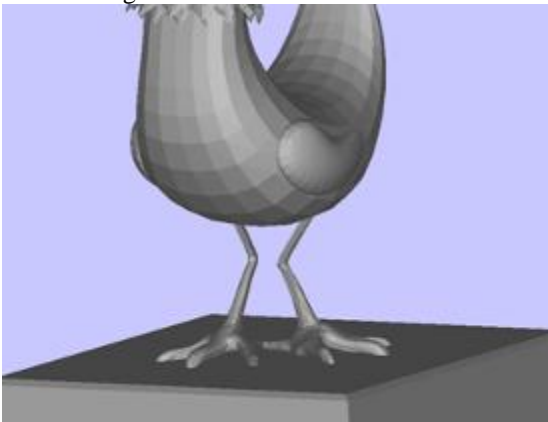


Figure 9, Original Rooster legs.

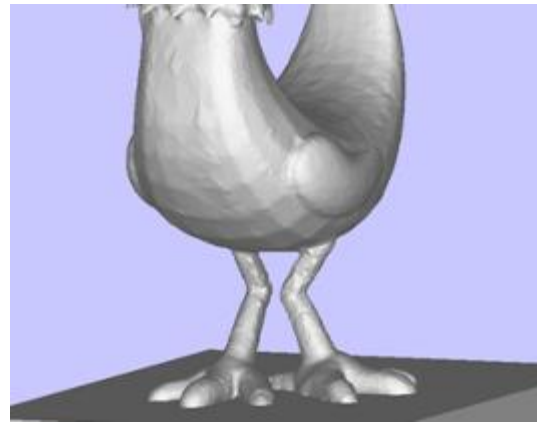


Figure 10, Thickened Rooster legs to support upper body.

If it is a small overhang, like clothing or a finger, it will probably be able to support itself. Please request advice if a feature needs to be smaller than .05 inches.

The Model Does Not Have Any Holes

All these triangles need to be connected to represent the complete exposed surface that encompasses a volume.

If a triangle, or even a complete surface, is missing, it is referred to as a hole. One way that a hole can be created is from an inverted normal. Each of the triangles (facets) described above has a side that reflects light (normal side) and a side that does not. When the side that does not reflect light is facing outward, it looks like there is a hole in the surface. This is called an inverted normal. The system will see this as an intentional hole and interpret the file as having infinitely thin walls without volume, much like the prior error. Only when a volume is completely enclosed by triangles, whose “normals” are all pointed outward, will it be considered a solid that is ready to be grown.

People often run into problems when trying to export a model using a quad format. These surfaces are made up of four points for every facet and if one of the four points is not exactly in the same plane as the other three, then it will create a hole because the system cannot use the supplied data. Three points are always better than four when trying to establish a flat plane.

There are some situations where “holes” are allowed. Consider a human model with a hand on its hip, the “hole” through the space between the hand and the body is not a hole in the surface describing the volume. Another type of hole that is acceptable is a hollow section within a model. These models must have a second surface to represent the interior wall. Usually material will be captured within this hollow section and a small hole will need to be drilled in afterwards to extract it, or a small cylinder can be created that punctures the inner and outer wall of the 3D model before it is grown, shown in figure 11 & 12.



Figure 11, Toy head with hollow inside.

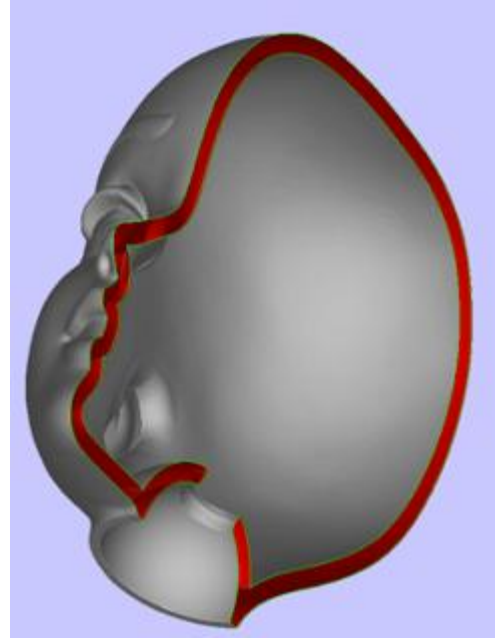


Figure 12, Section cut showing hollow inside and hole to extract inner material.

There are no Intersecting and/or Overlapping Surfaces

In many 3D modeling programs, a visual representation can be quickly made by just sketching out surfaces and getting them close enough to look good. When trying to grow an object with volume, “close enough” is not good enough. All surfaces have to be connected at the corners to create one continuous mesh.

Figure 13 shows intersecting surfaces that need to be trimmed to look like figure 14.

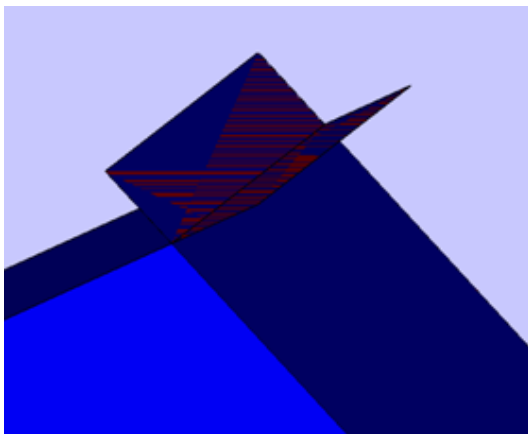


Figure 13, Edge with intersecting surfaces.

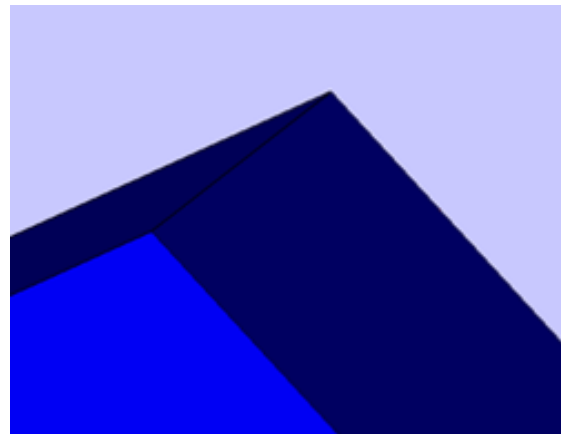


Figure 14, Corrected edge with surfaces joined at single point.

Often users will overlay surfaces to cover gaps. This is considered to be an overlapping surface and the machine will not be able to process the data correctly, all edges of a facet must meet at the same common point just like above.

Make sure that all vertices that occupy exactly the same co-ordinates are also welded together. Often when two pieces of geometry are attached and the vertices are just “snapped” together it appears as though a single vertex exists when in fact it is often two or more sharing the same position. If there are multiple edges and/or points in the same place it can cause errors much like a hole.

Colors are Applied to Each Facet on a Surface rather than just “Texturing”

This rule only applies to models that will be created on our full color machine. Normally the color of a model is the direct result of the material color that is being used. Our Spectrum Z510 is the exception to this rule and can create full color models by literally printing colored inks onto the surface of the model as it is growing.

Many CAD packages allow users to apply “textures” to a model to make the surface look like skin or hair, etc. These textures are often just visual representations and not actually being applied to the surface of the object. In this case, when a model is exported to be printed, the colors will not be exported with it and the model color will result in the base material color (white in this case).

On the other hand, some CAD packages will apply the texture directly to the surface and the exported model will be in full color. The best way to make sure your software will export the proper surface is to save the file as a .VRML (the standard for color files) and re-open it in your software to see if the color remains on the model. If you cannot save your model as a .VRML, there are other formats that we can use to convert it to a .VRML but please consult with us before trying different formats. A .VRML file, shown in figure 15, is much like the triangulated .STL format, shown in figure 16, with the exception that it applies the corresponding color to each facet to make up the full surface.



Figure 15, Full Color .VRML file.

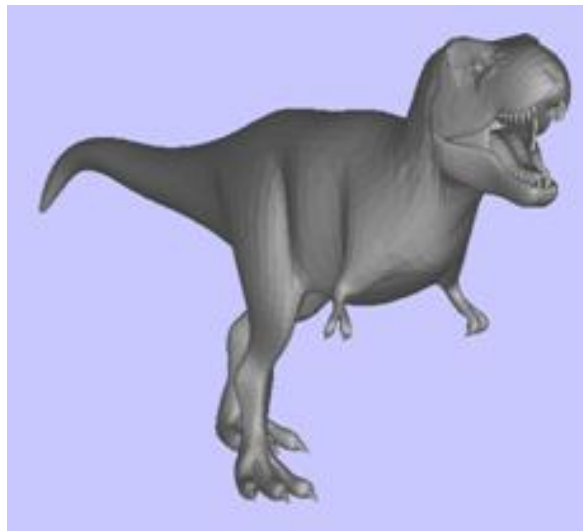


Figure 16, Equivalent .STL file.

The Model Contains One Solid Object

The one exception to this rule is when using the new Connex 500. If you would like to grow a model using multiple materials and flexibilities, please contact us before modifying the model.

For all other models, the 3D file needs to be represented by a single volume, also known as a shell. If a model is created using multiple shells that intersect each other, each shell will need to be connected and any resulting interior surfaces should be deleted. If an interior surface is left as part of the model, the system could run into an error and have to stop, or possible integrity and/or quality issues can result. Shells can be combined many different ways. One of the most common ways is by using a boolean command with a “unite” option. This will take two separate shells and combine the external surfaces and do all the necessary stitching at the edges to eliminate the internal surfaces.

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