FDM BEST PRACTICE:

CREATING VARIABLE DENSITY PARTS

Stratasys®
3D Printers and Production Systems

SOFTWARE/PRODUCT/FINISHING

OVERVIEW

A unique characteristic of FDM® technology is that a single part can have regions with different build styles, which can be used to make a part with variable densities. Unlike default interior styles, such as solid or sparse that are applied to the entire part, variable densities allow a single part to have combinations of solid and sparse fill styles, and each region's density can be adjusted independently (Figures 1 and 2). With just a few minutes of extra design and pre-processing, you can save hours of build time and/or dramatically improve the part's properties.

The advantages of variable density parts are:

- Optimized strength, weight and performance
- Reduced build time and cost
- Enable niche applications (e.g., end-use parts, fiber molding and thermoforming)

Variable density parts are created using a combination of 3D computer-aided design (CAD) and Insight™ software. For complete control over each region, the 3D CAD model is split into sub-components and each may have a unique density. Each sub-component is processed with different toolpath options (Figures 3 and 4). The use of variable density is common when optimizing a design for functionality. For example, solid fill is used where additional strength is needed, while the remainder of the part is built using sparse fill.

NOTE: Descriptions of all the parameter sheet options are available through the Insight software help menu. Many of these settings can have detrimental effects on your parts if not used properly. Therefore, it is recommended that only experienced users make changes to these values. To ensure the best possible part quality, Stratasys® recommends that you always review the toolpaths on your parts and make modifications if necessary, before downloading them to your system.

Reference materials:

- Video
  - Show Me How
- Processes
  - Best Practice: CAD to STL

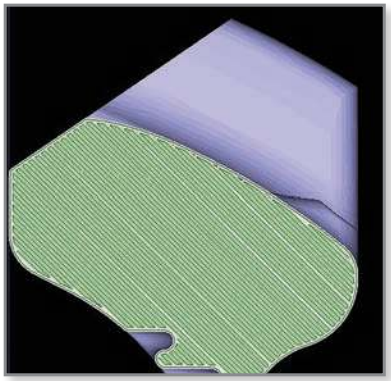

Figure 1: Solid-normal fill throughout part.

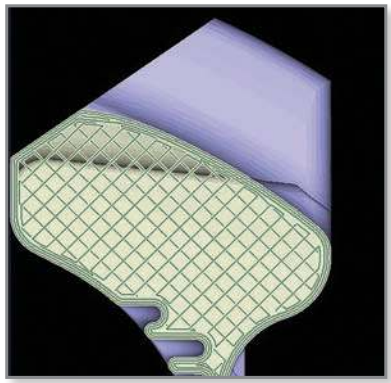

Figure 2: Sparse-double dense fill throughout part, including narrow section.

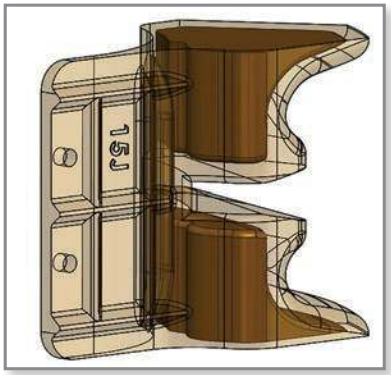

Figure 3: Transparency showing two regions of a single part.

1. PROCESS

1.1. Modify the CAD model.

STEP 1: Open the CAD model to be produced with variable densities (Figure 5).

STEP 2: Add a reference feature (square extrusion) at the origin making it slightly taller than the part. This will assist with alignment of the various regions within the Insight software (Figure 6).

STEP 3: Save the model.

STEP 4: Extract a sub-region along with the reference feature from the complete CAD model (Figure 7), and then delete the balance of the model (Figure 8).

STEP 5: Offset surfaces that mate with the main structure, giving a clearance of 0.03 mm (0.001 in).

NOTE: Insight software will combine curves that mate or overlap, eliminating regions from a main structure.

STEP 6: Export this file as an STL.

TIP: Large facets can create regions of overlapping curves between parts. This can create problems during toolpath generation. To avoid this, use small facets and visually inspect all layers after toolpath generation in the Insight software. For details, see the *Best Practice: CAD to STL*.

STEP 7: Reopen the original CAD file and extract the next region. As with the first, retain the reference feature while deleting the balance of the model.

STEP 8: Repeat Steps 4 through 6 until all desired regions are created.

1.2. Process regions using the Insight software.

STEP 1: Configure the modeler.

STEP 2: Open and orient the STL, confirming that the reference feature is located at the origin.

STEP 3: Click  to create part curves using the current parameters.

STEP 4: From the ***Toolpaths*** menu, select ***Custom groups***.

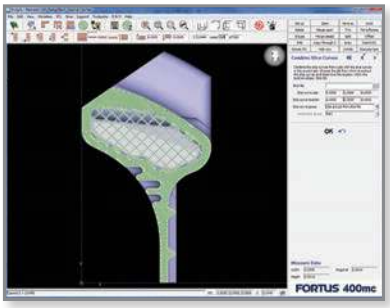

Figure 4: Result of variable density combining solid and sparse fills.

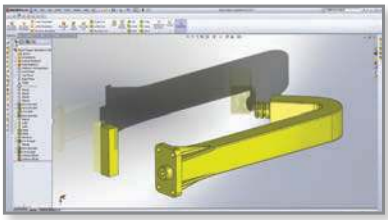

Figure 5: Original CAD model of robot gripper arm with reference feature at the origin (0, 0, 0).

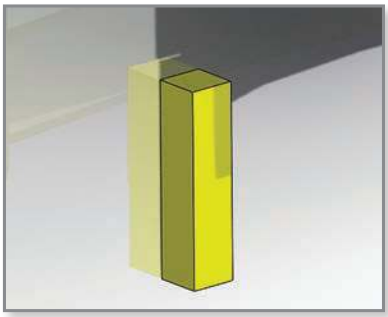

Figure 6: Reference feature (square extrusion) located at the origin.

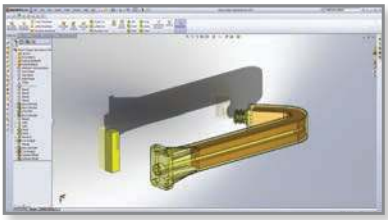

Figure 7: Region one (opaque-center) and region two (transparent-yellow outer area).

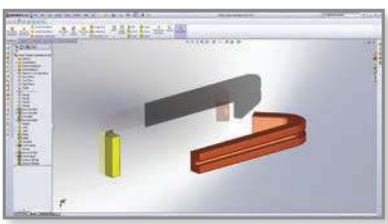

Figure 8: CAD model of region one with reference feature.

STEP 5: Click **New** to create a new custom group and adjust the parameters to achieve the desired characteristics for the region. For example, change the part interior style to ***Sparse-double dense*** through ***Custom Groups*** (Figure 9).

STEP 6: Click ✔ to confirm your selection.

STEP 7: Select the desired curves using your cursor and click **Add** . All curves that are added to this group will have the toolpath parameters you defined.

STEP 8: Save the job.

STEP 9: Repeat Steps 2 through 8 for all but the last region.

NOTE: Every region must use the same ***Model material***, ***Slice height*** and ***Orientation***.

STEP 10: Open, orient and slice the last STL file and then apply the desired toolpaths by using ***Custom Groups*** (Figures 10 and 11).

STEP 11: Save the job and keep it open.

STEP 12: Click ***Combine slice curve files*** located in the ***Slice*** drop-down menu and import the sub-regions into the job.

STEP 13: Position sub-regions within the job by entering the ***Slice curve location*** (0, 0, 0). The reference feature will ensure all regions are aligned properly (Figure 12).

NOTE: An overlapping toolpaths warning will appear. Click **OK** to disregard.

STEP 14: Select and delete the curves for all of the reference features by using the ***Delete*** operation located in the edit drop-down menu (Figure 13).

TIP: Use the ***Curve selection menu*** to assist with selection of multiple curves.

STEP 15: Save the job.

STEP 16: Creating Variable Density Parts procedure complete.

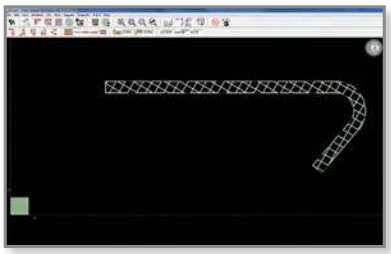

Figure 9: First region has a Sparse - double dense fill with no external contours.

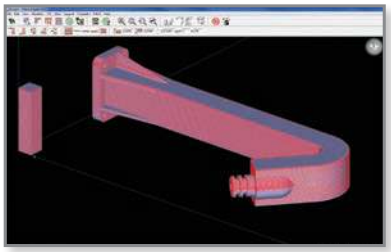

Figure 10: Open and slice the second region.

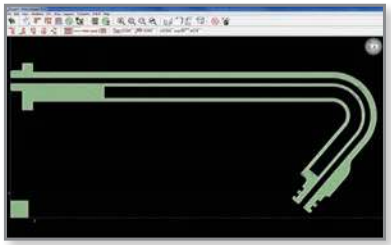

Figure 11: Fill style for the second region is Solid.

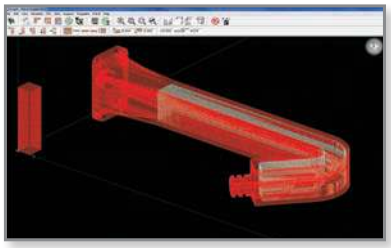

Figure 12: Combine both regions and process for building.

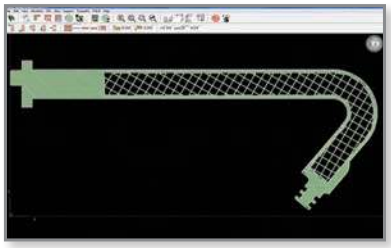

Figure 13: Resulting variable density part.

2. TOOLS & SUPPLIES

2.1. Software:

- 3D Computer-Aided Design (CAD) Software
- Insight software (documented with Insight 9.0)

CONTACT:

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