FDM MATERIAL GUIDE

FDM Nylon 12CF

Overview

FDM Nylon 12CF™ is a chopped carbon fiber-filled (35% by weight) polyamide 12, available on compatible Fortus® Production Systems. The material has a high strength-to-weight ratio and a tensile strength on par with other high-performance FDM® materials. It has the highest specific modulus of any FDM material. Due to the unique directional orientation of carbon fibers (Figure 1), the material exhibits anisotropic properties that can be tailored similar to a composite laminate. This enables parts to have a higher uniaxial stiffness than injection molded parts of the same material. It opens up unique design freedoms, not present in either traditional thermoplastic or additive manufacturing.

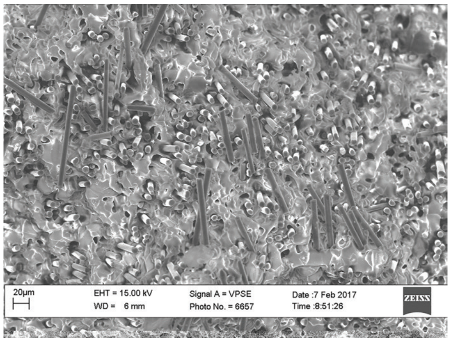

Figure 1: SEM image, top-down view of the filament cross-section showing the fiber alignment in the direction of extrusion.

These characteristics make FDM Nylon 12CF a good fit in a variety of functional prototyping and tooling applications in the following industries:

- Aerospace – UAV components and tooling
- Transportation and auto – bumpers, fixtures and brackets
- Consumer – performance sporting goods
- General manufacturing – tooling, fixtures and other manufacturing aids

Pre-processing – In addition to standard STL processing procedures, proper configuration of the modeler and modification of build parameters can dramatically impact the mechanical properties and build quality.

Machine preparation and printing – When packing parts for a job using Control Center™ software, proper placement and orientation of the part on the build platen and machine maintenance considerations are critical to success.

NOTE The XYZ tip offset calibration is extremely important. Carefully follow the procedure outlined in Section 2.1.2 to prevent build failure or loss of extrusion due to improper tip offset calibration.

Post-processing – Proper part removal from the build chamber and proper support removal technique can improve user experience and quality of the resulting parts.

1. PRE-PROCESSING CONSIDERATIONS

1.1 PREPARE PART FILE USING INSIGHT™ SOFTWARE.

1.1.1 Part orientation

Because the FDM process results in anisotropic surface finish and mechanical properties, proper orientation is dependent on the part's function. For functional or production parts, build orientation should be selected based on the forces acting upon the printed part. By selectively orienting the part to avoid excessive stresses on thin geometries or in the z-direction, the mechanical properties of critical features can be optimized. For conceptual models or parts where aesthetics are most important, orientation should be selected to reduce the appearance of layer lines on critical surfaces. For more information, reference the **Best Practice: Orienting for Strength, Speed or Surface Finish**.

1.1.2 Build mode selection

The default build mode is ***Normal***, which is recommended for most geometries (Figure 2). For thin walled parts (sections thinner than 0.508 mm [0.2 inches]), or with small individual parts that show signs of the part melting when printed using the default build mode, utilize the ***Thin wall mode***. The ***thin wall mode*** reduces the oven temperature and the likelihood of melting on thin walls and small individual parts.

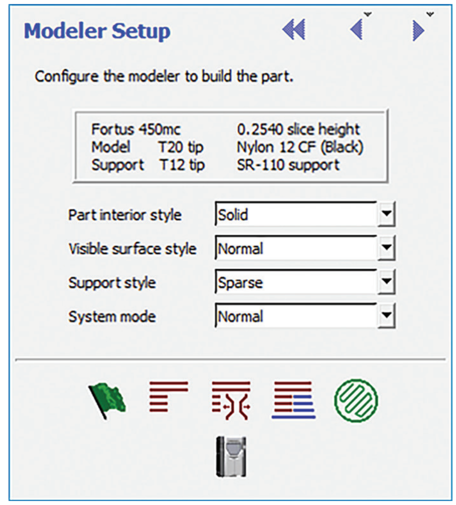

Figure 2: The System Mode, Part Interior Style, and Support Style can be selected in Modeler Setup.

1.1.3 Build style selection

The default build style for FDM Nylon 12CF is ***Solid***. The ***Sparse*** fill style is also available and will reduce material consumption.

NOTE ***Sparse - double dense*** is not a fill style option for FDM Nylon 12CF. Instead, users should create a ***Custom Group*** and select the ***Alternate sparse fill style*** as ***Sawtooth***.

1.1.4 Toolpath parameters

It is recommended to use the default raster and contour widths of 0.508 mm (0.020 in.).

NOTE Avoid using contour widths thinner than the defaults as it can result in inconsistent surface quality and finish.

1.1.4.1 Raster angle –

The default raster angle is 45° with a delta angle of 90° every layer. Modification of the raster and delta angle may improve the mechanical properties as measured in certain directions, but may also result in part curl in some combinations.

NOTE For thin flat parts and sections (less than 10 layers) and an even number of layers, symmetry about the mid-plane must be maintained by using ***Custom Groups*** (Figure 3). Create a new ***Custom Group*** and modify the raster ***Start angle*** to be equal to 0° or 90°. Add the mid-plane to the newly defined ***Custom group***; maintain the default raster angles for all other layers.

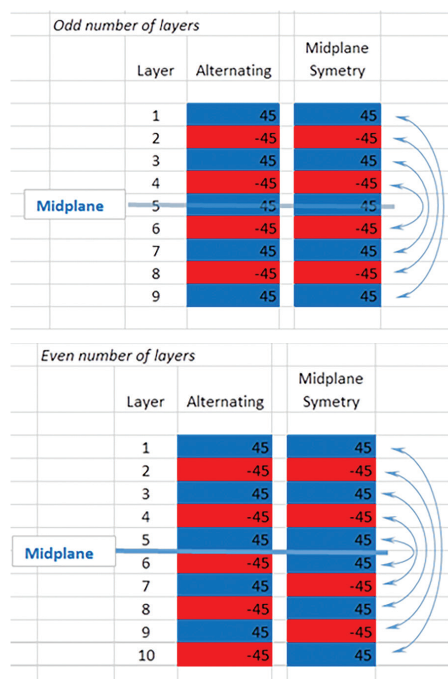

Figure 3: Schematic showing the difference in mid-plane symmetry for an odd and even number of layers. To maintain symmetry about the mid-plane when there is an even number of layers, a change in raster angle may be required.

1.1.4.2 Seam control

The seam location is where the material extrusion toolpath starts and ends on each closed part curve. The recommended seam placement method is ***Align*** or ***Align to nearest*** as it yields better surface quality. Seam Control is accessed from the ***Toolpaths*** menu. For more information, reference the B***est Practice: Optimizing Seam Location***.

NOTE For thin parts, avoid placing seams directly on the edge of the part.

1.1.5 Support parameters

Due to the mismatch in the coefficient of thermal expansion between the model and support material, the support parameters must be set to prevent build issues or support-removal issues.

1.1.5.1 Use model as support

In the ***Support Parameters*** dialog box, the checkbox for ***Use model material where possible*** is selected by default (Figure 4 - next page). This reduces the impact of the mismatch in the coefficient of thermal expansion between the model and support materials on the part. Additionally, the time that the model tip is the inactive tip is shorter, which also minimizes the potential for extraneous model material to be deposited into the part.

NOTE For parts greater than 76 mm (3 in.) in height, the ***Use model material where possible*** option must be enabled due to the differential in shrink rate between the model and support materials.

1.1.5.2 Support style selection

The support style is configured in ***Modeler Setup***. The default support style is ***Sparse***. ***Sparse*** or ***Basic*** support styles are recommended for most builds. The exception is if the part contains internal channels or cavities where the model material used as support may become trapped and difficult to remove. For parts with internal channels and cavities, the recommended support style is ***Box***.

1.1.5.3 Box support style

Box support is similar to sparse supports, but consists of boxes instead of continuous raster. There is no closed toolpath-perimeter curve around the box supports. Box supports will build more slowly than sparse supports. By default the ***Box partition size*** is set to 12.7 mm (0.5 in.) which limits the length of the partitioned supports.

When using the ***Box*** support style with the ***Use model material where possible*** option selected, there is an option to ***Partition box supports***. When this is enabled, the user has the option to select the ***Box partition size*** from a drop-down menu. When the option for ***Partition box supports*** is enabled, the default partition size is 12.7 mm (0.50 in.). This is the recommended partition size unless the part geometry requires otherwise. Using this option can improve both the manual and automated support removal processes.

NOTE The use of a partition size smaller than the default is not recommended unless it is required for the partitioned model-as-support to be removed from an internal cavity. In this case use the largest partition size that will still allow the supports to be removed.

For parts that contain delicate or fine features, use a partition size of 6.35 mm (0.25 in.).

1.1.5.4 Perforations

When using model as support, in the ***Support Parameters*** dialog box ensure that the checkbox for ***Insert Perforation Layers*** is selected with an interval height of 12.7 mm (0.50 inches) and ***Number of Layers*** set to 2 (Figure 4). For models that have nearly enclosed cavities, set the ***Number of Layers*** to 3 and adjust the intervals so that the "boxes" of model-as-support can be removed from the cavity once the soluble support material is dissolved.

NOTE Take care when performing the XYZ tip offset calibration because a poor calibration can result in long dissolution times for the perforation layers in box supports, or incomplete perforation. Both will result in difficulty removing the support from internal cavities.

1.2 BUILD PREPARATION USING CONTROL CENTER SOFTWARE

1.2.1 Part Placement

Due to the airflow configuration of the Fortus system, proper part placement can prevent and alleviate quality issues.

- **Single Parts** – Place near the center of the platen.

NOTE For single parts that are less than 12.7 mm (0.50 in.) in cross-section, add a full height "purge part" to the pack or build an additional copy of the part. This will result in improved surface quality compared to the single part.

- **Multiple Parts** – Place in the center and move concentrically outwards.
- **Mixed Pack** – Place the tallest parts in the center and move concentrically outwards. Place parts with thick-wall sections to either side (left or right) of the platen. Avoid placing thin-walled parts to the rear of the platen.

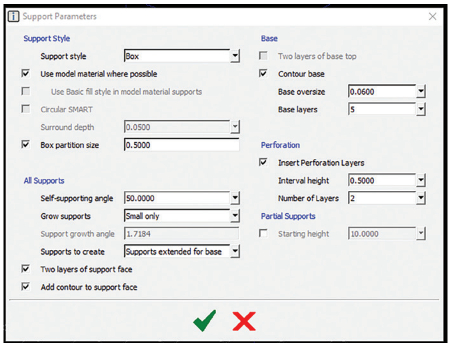

Figure 4: Changes to the Support defaults can be made in the Support Parameters, including Box partition size, Perforation interval and Layers of perforation.

Figure 5: A FDM Nylon 12CF part printed with sparse supports, using model as support where possible and two layers of perforation with a 0.5 inch interval.

1.2.1.1 Purge Tower

The purge tower is the first part built that improves the quality of the other parts in the pack. The purge tower is automatically placed in the right-front corner of the packed parts assembly, but can be repositioned by the user. The use of a **Full height** purge tower is the default setting and is recommended with all FDM Nylon 12CF builds.

STEP 1: On the ***Pack*** tab, click on the packing ***Options*** button.

STEP 2: In the ***Purge tower*** options drop-down menu, ensure the ***full height*** option is selected.

STEP 3: Click “OK” to confirm your selection.

2. MACHINE PREPARATION AND PRINTING

2.1 Machine Preparation

Proper machine preparation is important for safeguarding the machine against damage, but also to ensure good build quality. Follow regular maintenance outlined in the appropriate Fortus System User Guide. Also, ensure that each of the following items is completed when starting a job.

2.1.1 Maintenance

STEP 1: Clean the platen, empty the purge bin and vacuum the build chamber.

STEP 2: Inspect the gantry area, specifically the flexible heat shield that isolates the head and gantry area from the oven. If there is any black filament powder accumulating in the heat shield, carefully vacuum the area.

NOTE You may need to move the Y carriage assembly around in order to vacuum all of the filament powder. Take care not to disrupt or strike any of the electrical components or the belts.

STEP 3: Verify the flicker and brush assembly is clean and calibrated at the correct height.

NOTE The purged FDM Nylon 12CF material can build-up on the flicker; be sure to clear this material before starting the next job.

STEP 4: Verify the compatible head assembly is installed.

NOTE It is necessary to install a special head assembly (PN821726-001) on the Fortus 450mc™ printer when using FDM Nylon 12CF.

This head is capable of running ASA or FDM Nylon 12CF model materials. When a head is not installed in the Fortus production system, it should be stored in the provided docking container (Figure 6).

STEP 5: Install the appropriate model and support tips. Ensure that the tip shrouds are clean and undamaged.

Slice Thickness	Model Tip	Support Tip
0.254 mm (0.010 in.)	T20C	T12 SR-100

2.1.2 Load Material

STEP 1: Load the model and support materials.

NOTE The FDM Nylon 12CF filament is more brittle than other model materials and filament that is out of the canister may break during load and unload if it's bent or impacted. Some black filament powder may be present under the drive blocks during load and unload of the filament.

TIP The base nylon 12 material is hygroscopic. Load material into each available material bay to prevent excess ambient moisture from entering the filament tubes and degrading build quality.

If the machine is left in an idle state for multiple days, it is recommended you unload the filament from the machine and properly store it until printing resumes. This will prevent tip plugging and diminished part quality resulting from moisture-contaminated filament.

STEP 2: Install a Nylon build sheet and verify that vacuum is present.

TIP For best results, place the build sheet onto the platen in the concave-down orientation if there is a set to the sheet. If there is not a set to the sheet, place the sheet in the oven with the matte/rough side facing down.

NOTE Build sheets that have been exposed to moisture will make it difficult to establish vacuum. Ensure that the Nylon build sheets are properly stored in the sealed foil bag, with desiccant.

STEP 3: Perform XYZ tip offset calibration. Repeat until the support layer **measurement** is within ±0.0254 mm (±0.001 in). Be sure to inspect the profile and look for flat edges on the top and bottom. Repeat the calibration procedure if the top and bottom edges appear rounded. Failure to do so may cause poor adhesion between model and support layers, leading to part curl, overfill or tip plugging.

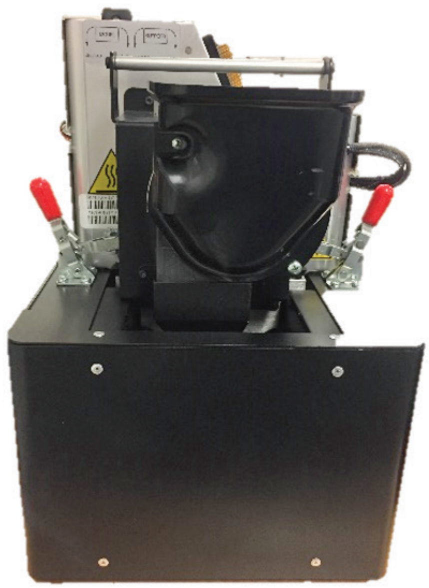

Figure 6: A compatible head assembly is required for FDM Nylon 12CF. The head assembly that is not in use should be properly stored in the docking container.

NOTE Part quality and support removability are directly related to accurate system calibration. X and Y offset must be within tolerance (±0.05 mm [±0.002 in.]). The Z slice variation is ideally within ±0.0127 mm (±0.0005 in.).

The calibration part used for FDM Nylon 12CF is modified to print faster (Figure 7). Although the appearance of the number labels and calibration box are different, the calibration is still performed in the same manner as other materials on the Fortus.

A blade can be used to assist in removing the support layer for measurement if it becomes difficult to peel off the entire layer.

STEP 4: Start the job.

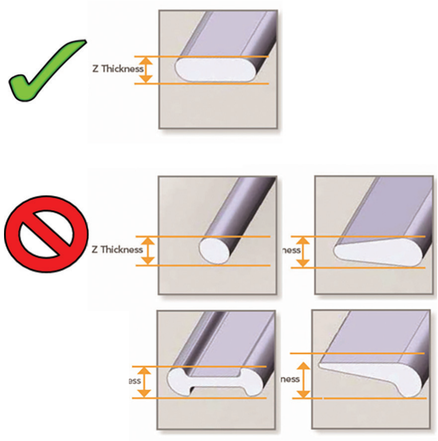

Figure 7: The calibration part used for FDM Nylon 12CF is modified to print faster.

2.2 REMOVE PART

Remove the build sheet and part from the build chamber. Wear appropriate personal protective equipment (PPE) when handling because the parts may be sharp, posing a danger of minor scrapes, scratches or splinters. To prevent part warping, allow the part and build sheet to cool before removal. The build sheet can become quite brittle as it cools down and may break off in pieces when removing the part from the sheet.

TIP The part may sometimes appear to change geometry as it cools. It will typically return to the nominal geometry upon soluble support removal.

2.3 REMOVE SUPPORT

2.3.1 Soluble support removal

Large support structures may be manually removed before placing the part in the support removal tank, but this is not required. Parts with the recommended ***Use model material where possible*** option enabled should be placed into a mesh bag or container, then placed into a tank of WaterWorks™ solution set at 60 °C (140 °F) until soluble support is fully dissolved (typically 1 hour minimum). The mesh container prevents the non-soluble model-as-support from floating freely and damaging the impeller of the tank. After the parts are removed from the WaterWorks solution, they should be rinsed thoroughly and dried.

2.3.2 Support removal technique

Some manual support removal may be required even after the soluble SR-110™ support is dissolved away. Remaining supports have a weak mechanical bond to the model and can be removed with pliers or a pick.

2.4 FINISHING

Parts can easily be sanded to make the surface smoother or more uniform in appearance.

3. SAFETY

Observe manufacturer recommendations for safety, material handling and storage. This information can be found in the Safety Data Sheet (SDS).

Recommended PPE

- Gloves
- Protective eyewear

4. TOOLS & SUPPLIES

- Chisel
- Magnetic handle pick set
- Pliers
- Needle-nose pliers

5. MATERIALS & CONSUMABLES

- FDM Nylon 12CF (Fortus Plus)
- SR-110 (Fortus Plus)
- T20C Tips
- T12 SR100 Tips
- Nylon foundation sheet

6. SOFTWARE

- Insight software (document developed with Insight 11.0)
- Control Center software (document developed with Control Center 11.0)

7. PRINTER

- Fortus 450mc (licensed and configured for FDM Nylon12 CF)

CONTACT

For questions about the information contained in this document, contact Stratasys at www.stratasys.com/contact-us/contact-stratasys.

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