

# FDM BEST PRACTICE

# Curl Management

SOFTWARE/PRODUCT/FINISHING

#### OVERVIEW

Curl is defined as the distortion of horizontal surfaces caused by the shrinkage of a new layer as it's applied over the existing layers, causing those layers to deform. This can be a challenge with parts that have thick cross sections or large flat areas. Insight<sup>™</sup> software features several tools that can mitigate part curl even on the most challenging geometries.

#### 1. OPTIONS

#### 1.1. Base Layer Modifications

Two non-invasive ways to reduce part curl are to increase the support **Base oversize** and **Base layers** values in the Insight software **Support Parameters** dialog box. Change one or both values as needed to achieve the best results. These two options are ideal when used with standard and engineering-grade thermoplastics because they won't leave any residual marks on the part.

#### 1.2. Removing Perforations

For materials with breakaway supports the default support parameters add perforations (single model layers incorporated in the support at predetermined intervals) for ease of support removal. For geometries where a large amount of stress may induce curling, failure may occur at the perforation layer. Typically, these geometries have large areas of support and curling can be avoided by eliminating perforations.

#### NOTE

Consider the part geometry and support removal process when removing perforations. For intricate or detailed parts, removal of perforations is not recommended.

#### 1.3. Anchor Columns

On large flat parts (> 305 mm [12 in.] long and >12.7 mm [0.5 in.] thick) that have the potential to curl due to differential cooling, anchor columns may be used to secure the model to the base. The anchor column is made of model material and will need to be mechanically removed after the build. Placement and quantity will depend on the part's geometry and any observed curl in previous builds.

#### NOTE

If the surface quality of the downward-facing surfaces is important, consider using **Stabilize Wall** to secure the parts by its vertical surfaces. This method isn't as robust but can be less invasive while reducing part curl.



#### 1.4. Anchor Profiles

Anchor profiles offer the advantage of anchoring the part in a uniform manner around its perimeter. This manual process is typically used when anchor columns aren't sufficient to secure the part.

#### NOTE

Descriptions of all the options in the parameters sheet 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 or advanced users make changes to these values. To insure the best possible part quality, Stratasys<sup>®</sup> recommends that you always review the toolpaths on your parts, and make modifications if necessary, before downloading them to your system.

#### 2. PROCESS

- 2.1. Base Layer Modifications
  - STEP 1: From the Support menu, select Setup.
  - STEP 2: Click of access the Support Parameters.
  - STEP 3: In the *Base* section, make sure the checkbox next to *Contour Base* is checked (Figure 1).
  - STEP 4: In the *Base* section, increase the value in the *Base* oversize field.
  - **STEP 5:** In the *Base* section, increase the value in the *Base Layers* field to add additional layers.
  - **STEP 6:** Click **V** to confirm the change.
  - **STEP 7:** This completes the base layer modification procedure.

#### 2.2. Remove Perforations (Large Areas of Support)

- **STEP 1:** From the *Support* menu, select *Setup*.
- **STEP 2:** Click **Chief** to access the **Support Parameters**.
- **STEP 3:** In the *Perforation* section, clear the checkbox next to *Interval height* to remove all perforations (Figure 2).
- **STEP 4:** Click **V** to confirm the change.
- STEP 5: This completes the procedure to remove perforations.

#### 2.3. Anchor Columns

### NOTE

Create anchor columns prior to creating supports and toolpaths. The generated supports will recognize the anchor columns and trim against the column.

50	pport Style			456		
	Support style	SMART	• P	Two leyers of t	100.000	
r.	Use model material wi	here possible	P	Contour base		
r.	use Basic fill style a	n model material supports		Base oversize	0.0600	
r.	Circular SMART			Base layers	5	-
	Surround depth	0.0500	9			
			,	erforation		
AR	Supports		, r	Interval beight	1.0000	
	Self-supporting angle	43.0000	4	artial Supports		
	Grow supports	Small only	Э с	Starting height	10.0000	
	Support growth angle	1.7164	-			
	Supports to create	Supports extended for base	2			
ø	Two layers of support	face				
		and Read				

84	pport Style			60	e		
	Support style	Spense		Г	Two layers of b	sol top	
г	Use model material whe	ere possible		1	Contour base		
г	Use Basic Wilstyle in	model material supports			Babe oversize	0.0600	
П	DYLAR SMART				Base layers	5.	
	Summed depth	0.0500	1	_			-
				Per	foreton		
Al	Supports			F	Interval height	0.2500	
	Self-supporting angle	43.0000	-	Par	tial Supports		
	Grow supports	Small only	•	F	Stirtingheight	10.0000	1
	Support growth angle	1.7654	_				
	Supports to create	Supports extended for base	-				
Q.	Two layers of support	face					
-	Add permeter to supp	ort face					

Figure 1: Support Parameters dialog box in Insight software.

Figure 2: Clearing the checkbox in the Support Parameters dialog box to remove perforations.

- **STEP 1:** From the *Support* menu, select *Anchor column*.
- STEP 2: Specify the desired *Top diameter* and *Bottom diameter* (Figure 3).

NOTE

It is recommended to use uniform small-diameter anchors. The columns should be wider at the interface with the build sheet and smaller at the part interface. This will minimize any witness marks when the anchors are removed while increasing the adhesive force, which prevents curling.

- **STEP 3:** Find the bottom layer of the part feature that will be secured using the anchor column. The next step is best done from a top-down view.
- **STEP 4:** Position the cursor on the location where you want to put the anchor column and left click. The center point of the selected location will populate (Figure 4).
- STEP 5: Click **OK** to confirm the anchor column location.

#### TIP

Because the anchor column will be generated from the base to the layer below the displayed layer, nothing will change in the current view. You may scroll down one layer to confirm placement.

**STEP 6:** Repeat the procedure to place any additional anchor columns.

#### NOTE

All anchor columns must be placed and confirmed before support is generated.

STEP 7: This completes the procedure for creating anchor columns.

#### 2.4. Anchor Profiles

**STEP 1:** Configure the modeler.

#### NOTE

#### Import using the appropriate scale.

- STEP 2: Open and orient the STL.
- **STEP 3:** Click **t** to create part curves using the current parameters.
- **STEP 4:** From the *Support* menu, select *Setup*.
- **STEP 5:** Click of access the **Support Parameters**.
- STEP 6: In the Supports to create section, select Supports extended for base. In the Base section, make sure the

that su	urface. OK to create o	column.
	Top diameter	0.1000
	Bottom diameter	0.1250
	Center point	7.5426 5.4189
	Column top laver	0

Figure 3: Specifying the anchor column dimensions.



54	port Style			Sat	se		
	Support style	Sparse	1	R	Tyje layers of b	asa top	
г	Use model material why	ere possible		4	Contour base		
Г	Use Basic fill style in	model material supports			Base oversize	0.0000	
Г	Onsiler SMART				Base layers	5	
	Surround depth	0.0500	1				
				Per	foration		
4	Supports			Г	Interval height	0.2500	
	Self-supporting angle	43.0000	3	Pa	rtal Supports		
	Grow supports	Small only	-	Γ.	Starting beight	2.0000	-
	Support growth angle	1.7184	-112				
	Supports to create	Supports extended for base	-				
ø	Two layers of support	face					
Γ.	Add perimeter to supp	ort face					

Figure 5: Ensuring the proper parameters are selected when generating supports in Insight software.

checkbox next to *Contour base* is checked and change the *Base oversize* to 0.0000 (Figure 5).

#### TIP Ensure *Perforation: Interval height* is unchecked.

- **STEP 7:** Click 🗮 to create supports for the current job.
- STEP 8: From the *Edit* menu, select *Copy Curves Through Z* to extend the outer perimeter model contour down to the build sheet. Change the *Copy mode* to *Specify through Z coordinate*. Enter the desired value into the *Through Z height* field (in this case: -0.0400). Change the *Destination group* to *Same as selected* (Figure 6).
- STEP 9: From the *Edit* menu, select *Offset Curves* to offset the outer perimeter model contour inward. Change the *Offset direction* to *Inside closed curve*. Enter the desired value into the *Offset distance* field (in this case: 0.0200). Change the *Destination group* to *Same as selected*. Change *Keep original* to *Yes* (Figure 7).
- STEP 10: From the *Edit* menu, select *Copy Curves Through Z* to extend the new inner perimeter model contour down to the build sheet. Change the *Copy mode* to *Specify through Z coordinate*. Specify the desired value into the *Through Z height* field (in this case: -0.0400). Change the *Destination group* to *Same as selected* (Figure 8).
- STEP 11: From the *Edit* menu, select *Offset Curves* to offset all of the support contours that are outside of the outer perimeter model contour so that they are inside the new inner perimeter model contour. Change the *Offset direction* to *Inside closed curve*. Specify the desired value into the *Offset distance* field (in this case: 0.0700). Change the *Destination group* to *Same as selected*. Change *Keep original* to *No* (Figure 9).

STEP 12: Generate toolpaths (Figure 10).

STEP 13: This completes the procedure for creating anchor profiles.

#### TIP

Once the parts have been printed, the anchor profiles can be removed by slitting the profile and peeling the profile contour off of the part.

#### TIP

A hot air welding tool can be used to remove white "haze" that might be present after removing the anchor profile.

#### 3. SAFETY

Observe manufacturer's recommendations for safety, material handling and storage. This information can be found in the safety data sheets (SDS).

	Copy mode	Specify through Z coordinate	-
	Through Z height	-0.0400	
	Through Z layer	1	
Г	Offset direction	Outside closed curve	-
	Offset distance	0.1000	
Г	XY shift delta	0.0000 0.0000	
	Destination group	Same as selected	-

Figure 6: Extending the outer perimeter model contour to the build sheet using the Copy Curves Through Z options.

onoce our res		
Select curves to offset. D offset direction. Keep orig and solids to holes. Retain the original curves.	etermine offset distan inal may change holes in part features by not i	te and to solids keeping
Offset direction	Inside closed curve	-1
Offset distance	0.0200	
Destination group	Same as selected	- <u>-</u>
Keep original	Yes	-
	Select curves to offset. D offset direction. Keep ong and solids to holes. Retain the original curves. Offset direction Offset distance Destination group Keep original	Select curves to offset. Determine offset distant offset direction. Keep original may change holes and solds to holes. Retain part features by not the original curves. Offset direction Inside dosed curve Offset distance 0.0200 Destination group Same as selected Keep original Yes

Figure 7: Offset the outer perimeter contour using the Offset Curves menu options.



Figure 8: Extending the inner perimeter model contour using the Copy Curves Through Z menu options.

## **CURL MANAGEMENT**

#### 4. SOFTWARE

- Insight software (documented with Insight 10.4)
- Control Center<sup>™</sup> software (documented with Control Center 10.4)

#### 5. MATERIALS

5.1. All Fortus® Materials



Figure 9: Offset all the support contours using the Offset Curves menu options.



Figure 10: Generating the toolpaths.

#### CONTACT

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



E info@stratasys.com / STRATASYS.COM

#### HEADQUARTERS

7665 Commerce Way, Eden Prairie, MN 55344

- +1 888 480 3548 (US Toll Free)
- +1 952 937 3000 (Intl)
- +1 952 937 0070 (Fax)

2 Holtzman St., Science Park, PO Box 2496 Rehovot 76124, Israel +972 74 745-4000 +972 74 745-5000 (Fax)

#### ISO 9001:2008 Certified

© 2015 Stratasys. All rights reserved. Stratasys, FDM and Fortus are registered trademarks of Stratasys Inc. Insight and Control Center are trademarks of Stratasys, Inc. All other trademarks are the property of their respective owners, and Stratasys assumes no responsibility with regard to the selection, performance, or use of these non-Stratasys products. Product specifications subject to change without notice. Printed in the USA. BP\_FDM\_CurlManagement\_1215

The information contained herein is for general reference purposes only and may not be suitable for your situation. As such, Stratasys does not warranty this information. For assistance concerning your specific application, consult a Stratasys application engineer. To ensure user safety, Stratasys recommends reading, understanding, and adhering to the safety and usage directions for all Stratasys and other manufacturers' equipment and products. In addition, when using products like paints, solvents, epoxies, Stratasys recommends that users perform a product test on a sample part or a non-critical area of the final part to determine product suitability and prevent part damage.