FDM BEST PRACTICE:

ASSEMBLIES

Stratasys
3D Printers and Production Systems

SOFTWARE/PRODUCT/FINISHING

OVERVIEW

Using FDM® technology to build complete assemblies gives designers greater design freedom and eliminates the time required to assemble separate parts. (Figure 1)

The use of FDM technology enables:

- Internal moving parts
- Functional mechanisms

When designing an assembly with FDM technology, proper clearance between mating and rotating parts is required to allow for an accurate fit and function. The design of the part and build orientation both play an important role.

Companion and reference materials:

- Reference Processes
  - Best Practice: *CAD to STL*

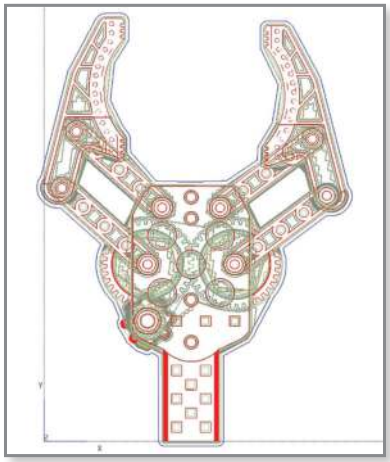

Figure 1: Complete Assembly (Slice curves).

1. OPTIONS

1.1. Orientating Parts for Assemblies

Before making design alterations it is important to have a strategy for the build orientation. Orientation of the mating components can affect the fit of the assembly and will determine the necessary clearances.

To achieve the most accurate fit, it is critical to position all mating components in the same manner relative to the XYZ axis (Figure 2). Choose an orientation for the entire assembly and build all components in the same orientation, as if they were assembled. Orient the mating surfaces in the X/Y plane whenever possible. The X/Y plane is the most accurate plane and is thus the best plane to orient critical mating surfaces.

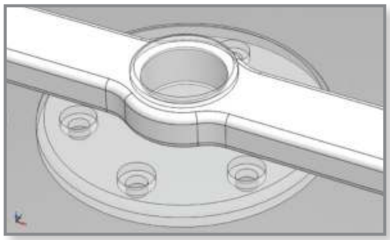

Figure 2: Properly aligned assembly components.

1.2. Design

Once the build orientation has been selected, the proper clearance can be designed into the part. This can be accomplished with the use of 3D computer-aided design (CAD) software, STL editing software, or Insight™ software. There are different clearance requirements based upon the FDM system and the alignment of the assembly features in the build.

Minimum Clearance Values (Fortus)

Model Material	Model Tip	Layer Thickness	Default Model Toolpath Width	Z Axis Clearance (Conservative)	Support Tip	X/Y Axis Clearance (Default Support Toolpath Width)
ABS PC-ABS	T10	0.13mm (0.005")	0.31mm (0.012")	0.25mm (0.010")	T12	0.31mm (0.012")
	T12	0.18mm (0.007")	0.36mm (0.014")	0.36mm (0.014")	T12	0.31mm (0.012")
	T16	0.25mm (0.010")	0.51mm (0.020")	0.51mm (0.020")	T12	0.31mm (0.012")
	T20	0.33mm (0.013")	0.66mm (0.026")	0.66mm (0.026")	T12	0.31mm (0.012")
PC	T10	0.13mm (0.005")	0.31mm (0.012")	0.25mm (0.010")	T12	0.25mm (0.010")
	T12	0.18mm (0.007")	0.36mm (0.014")	0.36mm (0.014")	T12	0.31mm (0.012")
	T16	0.25mm (0.010")	0.51mm (0.020")	0.51mm (0.020")	T16	0.41mm (0.016")
	T20	0.33mm (0.013")	0.66mm (0.026")	0.66mm (0.026")	T16	0.41mm (0.016")
PC-ISO™	T12	0.18mm (0.007")	0.36mm (0.014")	0.36mm (0.014")	T12	0.31mm (0.012")
	T16	0.25mm (0.010")	0.51mm (0.020")	0.51mm (0.020")	T16	0.41mm (0.016")
	T20	0.33mm (0.013")	0.66mm (0.026")	0.66mm (0.026")	T16	0.41mm (0.016")
Nylon 12	T12	0.18mm (0.007")	0.36mm (0.014")	0.36mm (0.014")	T12	0.31mm (0.012")
	T16	0.25mm (0.010")	0.51mm (0.020")	0.51mm (0.020")	T12	0.31mm (0.012")
	T20	0.33mm (0.013")	0.66mm (0.026")	0.66mm (0.026")	T12	0.31mm (0.012")
ULTEM® 9085 Resin	T16	0.25mm (0.010")	0.51mm (0.020")	0.51mm (0.020")	T16	0.41mm (0.016")
	T20	0.33mm (0.013")	0.66mm (0.026")	0.66mm (0.026")	T16	0.41mm (0.016")
PPSF	T16	0.25mm (0.010")	0.51mm (0.020")	0.51mm (0.020")	T16	0.41mm (0.016")
	T20	0.33mm (0.013")	0.66mm (0.026")	0.66mm (0.026")	T16	0.41mm (0.016")

Table 1: Minimum Clearance Values (Fortus®)

Machine Tolerance (for X/Y-axis clearance)

FDM System*	Achievable Accuracy**
FDM System*	**Achievable Accuracy****
Fortus 900mc™	± 0.09 mm (± 0.0035 in) or ± 0.0015 mm/mm (± 0.0015 in/in)
Fortus 380mc™, 450mc™ (360mc™, 400mc™, Vantage, Titan, Maxum)	± 0.127 mm (± 0.005 in) or ± 0.0015 mm/mm (± 0.0015 in/in)
Fortus 250mc™	± 0.241 mm (± 0.0095 in)

**For FDM printers without a stated achievable accuracy (i.e. Dimension®, uPrint®, Mojo® 3D Printers), a clearance of ≥ 0.51 mm (0.020 in) is required between components in the X/Y-axis and a clearance equal to at least double the layer thickness for the Z-axis.*

***Accuracy is geometry dependent. Achievable accuracy specification derived from statistical data at 95% dimensional yield.*

Table 2: Machine Tolerance (for X/Y-axis clearance)

2. PROCESS

2.1. Assemble and Export the 3D CAD Model

STEP 1: Determine the orientation of the assembly.

STEP 2: Arrange components to create an assembly. Ensure the orientation matches the desired build orientation (Figure 2).

> **NOTE:** Ensure support material can be removed if using a break-away support material

STEP 3: Confirm individual part clearances are in accordance with the information listed in Tables 1 and 2. Make any necessary changes.

> **NOTE:** Use appropriate clearances (radial or diametrical) where appropriate.

STEP 4: Save all components of the assembly in a single STL file.

> **NOTE:** 1) Check for interferences between parts.
> 2) Faceting can affect part-to-part clearances. For details, see the Best Practice: *CAD to STL*.
> 3) Take note of the scale used when exporting. This will have to be matched when importing into the Insight software.

2.2. Confirm Clearances

STEP 1: Configure the modeler.

> **NOTE:** Import using the appropriate scale.

STEP 2: Open and orient the STL. Confirm that the assembly is oriented as it was designed.

> **NOTE:** 1) Do not scale a complete assembly in Insight software as this will also modify the clearances.
> 2) Do not rotate a complete assembly in Insight software (so that it is in a different orientation than when it was designed) because the clearances were designed for a specific build axis.

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

STEP 4: Click to create supports for the current job.

STEP 5: Click to create toolpaths.

STEP 6: Under the ***Toolpaths*** menu, select ***Shade toolpaths*** (Figure 3).

STEP 7: Right click anywhere in the viewport and select ***Snap-Measure*** from the menu. Drag the cursor to measure the clearance between model toolpaths (Figure 4).

STEP 8: Confirm that the clearances are in accordance with the clearances listed in Table 3.

STEP 9: View the individual layer slices by clicking on the  icon to view the layers from the front.

STEP 10: Confirm that a support layer exists between model layers (Figure 5).

STEP 11: If the clearances and support layers are correct, proceed to step 12. If the clearances are incorrect, modify the 3D CAD model accordingly and repeat procedures 2.1. and 2.2.

STEP 12: Assemblies procedure complete.

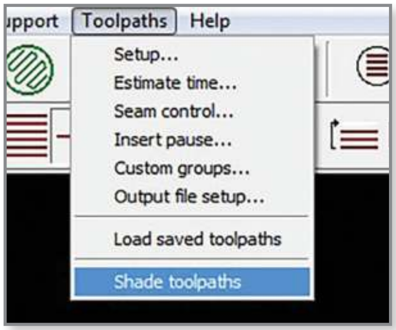

Figure 3: Toolpaths menu.

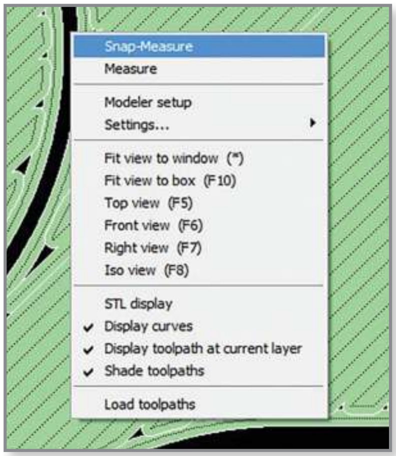

Figure 4: Snap-Measure tool.

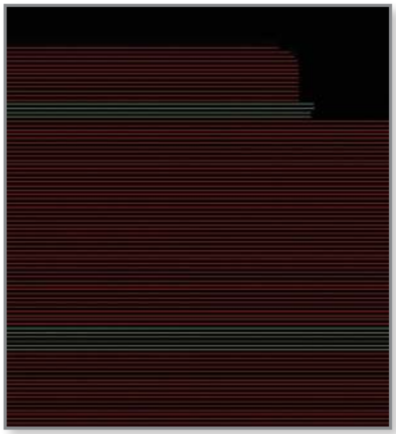

Figure 5: Support layers (white) between model layers (red).

3. TOOLS & SUPPLIES

3.1. Software:

- 3D CAD software
- Insight software (Document developed with Insight 9.0)

Figure 6: Mechanical assembly built fully assembled using FDM technology (ABS-M30™ Ivory).

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