



Guidelines for Preparing and Painting FDM Parts

Color brings a product to life. Color adds depth, contrast and character. And part of that character comes from the subtle differences in hues, shades and sheens. This is true for concept models, marketing samples and finished goods.

For product development and many production applications, paint provides the color. With a little know-how and a touch of patience, models and prototypes can be turned into eye-catching display samples. Under the coat of paint may be wood, metal or plastic.

The process of turning an FDM part into an eye-catching sample is no different from that for other plastic parts. Sand, fill, prime and paint...these are the four simple steps to make an FDM part come to life.



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1. Overview

1.1. Application:

Painted FDM parts are an alternative to machined and cast parts with a similar finish and small quantities of molded parts that do not require painting. Applications include:

- Concept models and communication aids.
- Sales and marketing samples.
- Pilot production runs.
- End-use parts.

1.2. FDM is a best fit when:

- Durable, stable parts are required.
- Parts have complex designs:
 - Feature-laden.
 - Internal ports, passages or channels.
 - Organic shapes.
 - Not recommended for very fine features (e.g., jewelry applications).
- Parts size:
 - No upper limit.
 - May bond sections to build large parts.
 - Lower limit: >1.0 in. (25 mm) in diameter.
- Small batches and low quantities.
 - Dependent on surface area, size and quality of finish.
 - Factors that affect the time to prepare for paint.
 - Typically 1 to 100 parts with high-grade finish.

2. Process Overview

The process for painting FDM parts is identical to that for any part.

2.1. Prepare surface.

- Fillers or putty to fill mars.
- Sanding to smooth surface.
- Clean and degrease for adhesion.

2.2. Apply primer.

- Spray multiple thin coats

2.3. Repeat sanding and filling as needed.

2.4. Paint part.

- Spray multiple thin coats.

2.5. Clear coat or texture (optional).

- Protects the underlying paint and gives depth, sheen to the part.

Note that the process, as outlined, will deliver a high-quality, painted part.



Figure 1: Two-piece MRI hand scanner painted to match production components.



Figure 2: MRI scanner assembly with two-tone paint.

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However, these steps are optional and may be used in any combination. For example, a quick concept model may only need a little degreasing and a coat of spray paint on the raw part.

Also note that the quality of the painted part will be dependent on:

- Quality of materials.
- Quality of tools and equipment.
- Skill and technique of the painter.

3. Cad & Design

No adjustments are required. However, two considerations may make the project a bit easier. (Figure 3)

3.1. Accessibility of features.

Every nook and cranny of the part will need filling, sanding and a coat of paint. Hard to reach areas or inaccessible features that may be unimportant could increase the time spent preparing and painting the part. So, look over the CAD model to determine if there are features that fit this description. If they exist, consider deleting them from the file.

3.2. Good STL resolution.

When creating the STL file, use small chord height, chord deviation and angle control. This produces a mesh with smaller facets, and smaller facets produce smoother surfaces that require less sanding (Figures 4 and 5).

4. File Preparation

4.1. Import the STL file into Insight and orient. (Figure 6)

4.1.1. **STL > Orient by selected facet** or **STL > Rotate**.

4.1.2. Considerations.

The following items are listed in descending order of importance. Note, however, that an optimal orientation requires all to be considered concurrently.

- For best surface quality:
 - Minimize visible steps.
- For best feature detail:
 - Minimize steps.
 - Locate contours in XY plane.
- For best strength:
 - Align layers perpendicular to force.
- For fastest process:
 - Minimize Z height.
 - Minimize post processing labor.
 - Support removal.
 - Surface smoothing.



Figure 3: CAD models of upper and lower housings for MRI scanner.

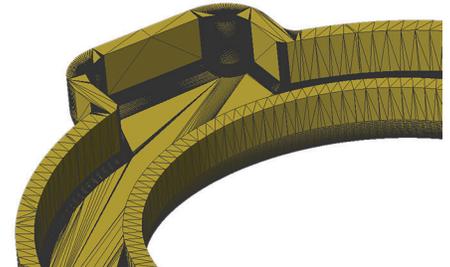


Figure 4: Smaller facets on a high-resolution STL file produces smoother surfaces.

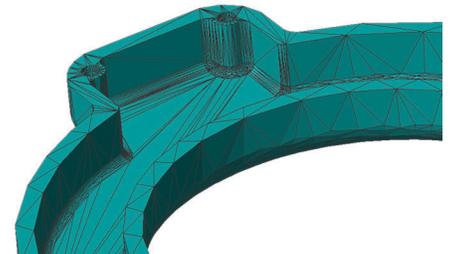


Figure 5: Coarser STL with larger facets will require more finishing work.

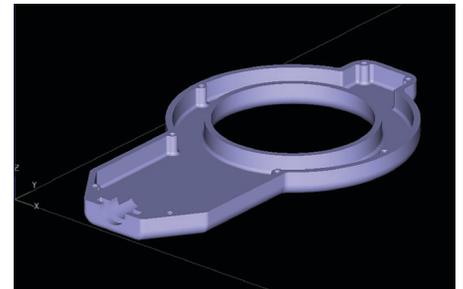


Figure 6: In Insight, import the STL file and orient it for the best combination of quality and process time.

4.2. Slice STL file.

4.2.1. Set Slice height (Modeler > Setup > Configure modeler). (Figure 7)

Consider using a fine Slice height.

Thinner slices will produce finer feature detail since the toolpath widths can be smaller. Thinner slices also produce higher resolution surface finishes because of smaller visible rasters and stair steps. The tradeoff is that thinner slices will increase build times.

4.3. Enable Enhanced mode.

4.3.1. Modeler > Setup > Visible surface style.

Enhanced mode produces smoother surfaces finishes while decreasing build times. It uses small raster widths on external, visible surfaces and larger rasters for the internal fill. (Figures 8 and 9)

4.4. Use support surface finish improvements.

These options improve the downward facing surfaces of parts where the supports interface with the model. These are all defaulted to “checked” for parts with soluble support material. Several options are not activated, by default, when using breakaway support material since removal may be more difficult if the supports trap features.

4.4.1. **Supports > Setup > Advanced parameters.** Check the boxes for:

- Two layers of support face.
- wo layers of base top.
- Add perimeter to support face.
- Double spacing between part and sparse supports.

5. Materials

All FDM materials can be painted. These include: (Figure 10)

- ABS, ABSi, ABSplus, ABS-M30, and ABS-M30i.
- PC, PC-ABS, PC-ISO.
- PPSF.
- ULTEM 9085.

5.1. Recommended materials.

When available, the ABS materials are preferred for painting projects. Surface preparation is usually easier, faster and less labor intensive. The ABS materials have soluble supports that eliminate manual removal. They also sand easily and can be smoothed with a chemical finishing process.

6. SURFACE PREPARATION

After constructing the FDM part, post process it to remove supports and finish the surfaces to the desired level of smoothness.

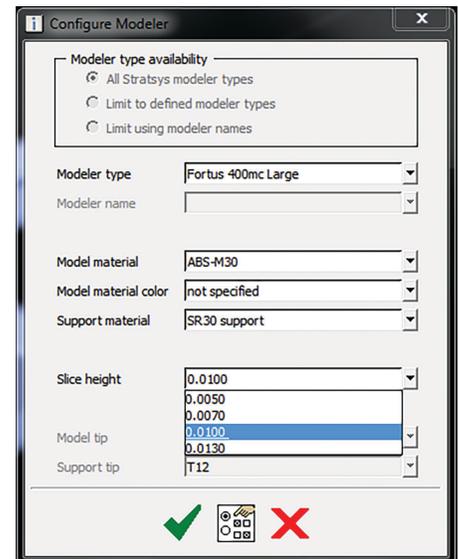


Figure 7: In Modeler > Setup, select a slice height for its surface finish and feature resolution.

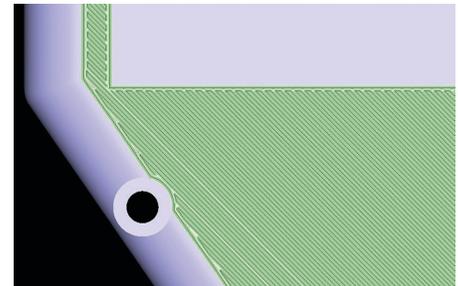


Figure 8: Toolpaths for visible surface are thinner and more densely packed when Enhanced Mode is used.

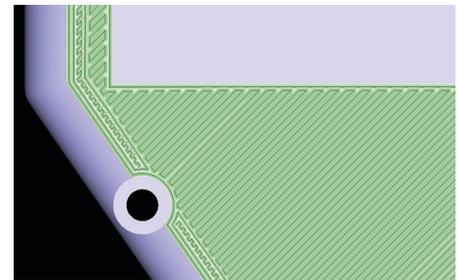


Figure 9: With Enhanced mode, the internal layers use larger rasters for faster builds.



Figure 10: FDM material sample display; all materials are paintable.

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6.1. Remove supports. (Figure 11)

6.1.1. Breakaway.

If the part is made of an FDM material that uses breakaway supports, manually remove them. When complete, clean it to remove any loose debris.

6.1.2. Soluble.

Dissolve the support material from the part following the instruction supplied with the soluble support solution. (Figures 12 and 13).

When no support material remains, remove the part. Then soak it in tap water and rinse (Figure 14) thoroughly to remove all traces of the support solution, which may react with or inhibit fillers, primers and paints.

Next, thoroughly dry the part to remove all moisture from within it. To accelerate drying, expose the part to hot, well-circulated air. Do not exceed 165° F (75° C) if using ABS.

6.2. Surface smoothing.

Primer and paint will not hide stair stepping and other surface defects. So, it is important to have smooth surfaces.

Surface smoothing may include any combination of chemical smoothing, sanding and filling. The following instructions prepare a part for a high-quality finish that mimics that from a polished injection mold. Surface finishing may stop at any point in the process, but note that paint will highlight imperfections. So, it is advisable to make the part a bit smoother than thought to be needed.

6.2.1. Chemical smoothing (optional).

Solvents will chemically melt the surface of FDM's ABS materials to produce a smooth, nearly paint-ready part. This approach may also be used with PC-based materials. 6.2.1.1. Finishing Touch Smoothing Station (ABS family only). This is the preferred method for chemical smoothing because it is fast, and it preserves dimensional accuracy and feature details. Parts are exposed to chemical vapors for 15 to 30 seconds (Figure 15). Repeat the process as necessary to reach the desired level of surface smoothness.*

Before proceeding to the next step, let the part set for 18 to 24 hours. This allows the surface to fully harden and all solvent to evaporate.

* See Finishing Touch Smoothing Station instructions for complete details.

6.2.1.2. Dipping and brushing.

Parts may be chemically smoothed with a manual solvent application. Either apply the solvent with a brush (Figure 16), or dip the part in the solvent (Figure 17).



Figure 11: Supports (milky white regions) are removed prior to finishing. Soluble supports shown.



Figure 12: Place part in support removal tank to dissolve the material.



Figure 13: Remove part from tank when no support material remains.



Figure 14: Thoroughly wash part to remove any residual solution.



Figure 15: Place part in smoothing chamber.

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Limit the duration of solvent exposure and avoid pooling in channels, pockets and corners. Overexposure will result in too much material being removed. And in some cases, it may cause the surface of the part to develop cracks, which must be repaired with filler. If applied with brush, allow the part to rest for 1 to 2 hours to let the surfaces harden. If dipped, allow it to rest overnight to ensure complete evaporation.

6.2.2. Degrease surfaces. (Figure 18)

Before application of fillers, putties or primers, wipe the part with a degreaser. This will remove contaminants and oils that may inhibit adhesion.

Apply a small amount of degreaser to a cloth and wipe all accessible surfaces.

6.2.3. Apply primer coat (optional).

A light coating of primer will reveal pits, pocks and stair steps. Many find that this makes the task of filling and sanding easier by drawing attention to the areas that need work (Figures 19 and 20). However, this step will add 1 to 2 hours to the surface preparation process.

- Option 1: standard gray primer.

Gray is common primer color, and it works well in showing surface defects. However, most other colors will also suffice.

This option is best when fillers will be applied to the part.

- Option 2: sandable primer.

Sandable primers have the advantage of self-leveling, which will aid in filling pinholes and layer lines.

Use this option if the primer coat will be followed by sanding.

With either option, apply a thin coat of primer and allow it to dry. See product instructions for drying times, which are typically 1 to 2 hours.

6.2.4. Apply body filler.

There are many types of body fillers, spot putties and glazing putties, and most are suitable for surface preparation. Select a filler for its viscosity, working time and drying time.

Recommendations:

- For larger layer lines and deep gouges:
 - 2-part glazing putties – low shrinkage.
- For small layer lines and pin holes:
 - 1-part spot putties – fast drying.



Figure 16: Solvents may be brushed on surface of ABS and PC parts to smooth them.



Figure 17: Alternatively, parts may be dipped in solvent.



Figure 18: Wipe all surfaces with a degreaser to ensure good adhesion.



Figure 19: A coat of primer will highlight areas that need sanding and filling.

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Working in small patches, spread the putty/filler on the surface of the part (Figures 21 and 22) to a depth that fills surface depressions without too much build-up in thickness.

Allow the material to dry and repeat until all areas are filled.

6.2.5. Sand surfaces.

After the body filler has dried, sand all surfaces to a smooth finish (Figure 23). If using a power-sanding tool, be cautious to avoid getting the plastic too hot.

Start with a coarse-grit wet/dry sandpaper (180- to 220-grit) and sand until the surfaces are visibly smooth. Complete this sanding step with fine-grit sandpaper (320- to 400-grit).

This is a good level of smoothness for most finish types.

6.2.6. Repeat.

Inspect the part. If visible depressions or defects remain, repeat the filling and sanding processes.

6.2.7. Clean part.

Remove dust and debris from the part before proceeding to the mold-making steps.

6.2.8. Apply primer.

Degrease the surfaces (Figure 24) of the part and apply two to three thin coats of primer. After each coat, allow the primer to dry (per manufacturer's instructions). (Figure 25)

6.2.9. Touch-up.

Following the primer application, visually inspect part for any remaining surface mars. If pinholes or blemishes are present, remove them with additional filling and sanding.

6.2.9.1. Fill.

Select a glazing putty (or similar) for filling small defects. These fillers will feather nicely and dry quickly.

As in earlier steps, apply the filler to the part and spread over any surface defects (Figure 26). Allow to dry per manufacturer's instructions.

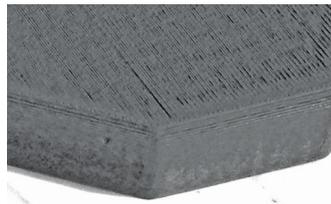


Figure 20: Close-up shows stairstepping and tool paths that need attention.



Figure 21: Apply a small amount of spot putty or body filler.



Figure 22: Spread the filler/putty to fill in depressions.



Figure 23: Allow filler to dry and then sand all surfaces to desired smoothness.



Figure 24: Between each step, clean and degrease surfaces to have good adhesion of filler, primer and paint.



Figure 25: Apply several thin coats of primer.



Figure 26: If surface imperfections remain, fill them with a glazing putty (or similar) that feathers nicely.

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6.2.9.2. Sand.

Sand the filler to smooth finish (Figure 27). As done previously, progress through 220-grit sandpaper to 320- or 400-grit. For a matte or textured finish, proceed to the next step after cleaning the part.

For gloss finishes, complete this step by sanding to reach a high level of polish. Wet sand all surfaces with a 600- to 800-grit wet/dry sandpaper.

Clean and dry all surfaces

6.2.10. Final primer coat. (Figure 28)

Degrease the surfaces of the part and apply two to three thin coats of primer. This primer coat ensures good paint adhesion and consistent appearance. After each coat, allow the primer to dry (per manufacturer's instructions).

7. Painting

The final step to a great looking part is applying the paint. Start by degreasing the part's surfaces and follow up with multiple coats of a good-quality paint (Figure 29).

There are two options for painting parts.

7.1. Option 1: spray can.

Spray paints have the advantages of being easy to use and not requiring additional equipment (e.g., spray gun). With a good-quality enamel paint and a well-ventilated space, anyone can paint FDM parts. Using good technique—thin coats, steady sweeps across the part and proper distance—the painted part will have a nice appearance.

Between coats, lightly sand the part after the paint has dried. This improves the bond for the next coat of paint.

As with all other steps, follow manufacturer's instruction for application and drying.

7.2. Option 2: spray gun. (Figure 30)

For a professional paint job, a spray gun and paint booth are a necessity. In the hands of an experienced painter, the spray gun's precise control will produce exceptional results.

Select a good-quality automotive or industrial paint. Adjust the spray gun's pressure and flow rates to lay down a thin, even coat of paint. Allow the paint to dry, then give it a light sanding and repeat. (Figure 31)

8. Optional Finishes

8.1. Textured paint.

To give the painted part some depth and texture, make a few changes to the way the paint is applied.



Figure 27 Sand the filler after it has dried.



Figure 28: After all filling and sanding is complete, apply final primer coats before proceeding to paint.



Figure 29: Using good-quality paint, apply several thin coats.



Figure 30: A paint spray gun, in the right hands, will produce professional results.

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Texture options are limited when using a spray can. A change in the distance from the part or the speed of travel will alter the finish somewhat, but be careful not to allow the paint to drip and run.

In the hands of an experienced painter, the spray gun can give the part a variety of finishes. Adjust the pressure (Figure 32) and flow rate on the spray gun. Also, change the distance from the part and the speed of the sweep across its surfaces. Note that there is a lot of technique needed for texture painting, so practice is a must before tackling a part.

8.2. Clear coat.

A clear coat is both decorative and protective. It gives “depth” to the painted finish with sheens that range from satin to high gloss. Clear coat also protects the paint from scratches.

Apply a clear coat in the same manner as the paint, using either a spray can or spray gun. After applying the final coat, allow it to dry for 24 hours and wet sand all surfaces to remove any texture. For wet sanding, select a sandpaper with 600- to 1500-grit.

9. Tools & Supplies

Note: Confirm the compatibility of the filler, primer and paint. Although infrequent, in some cases these materials may inhibit one another’s adhesion and curing.

9.1. Recommended items:

Specific products are listed below to assist in selection. However, substitutions may be made.

- Sandpaper: 120 – 1500 grit wet/dry.
- Chemical finisher (optional).
 - Micro-Mark SAME stuff, MEK, acetone or Weld-On #3.
- Degreaser: PPG DX330.
- Filler/putty:
 - 3M Acryl-Green Spot Putty.
 - 3M Acryl-Red Glazing Putty.
 - Other fillers/putties are suitable.
 - Suggested hardness—less than FDM’s ABS material to avoid excessive part surface removal.
- Primer:
 - Sandable: Plastikote T235.
 - Standard (gray).
- Paint:
 - Spray can: enamel.
 - Dupli-Color, Rustoleum, Krylon, Testors or Model Masters.
 - Spray gun:
 - Sherwin Williams, Polane T-plus, Cardinal Industrial Finishes (Pantone) or PPG.



Figure 31 : Between coats, lightly sand for adhesion and inspect for any surfaces mars.



Figure 32: For textured finishes, when using a spray gun, adjust pressure and flow rate.



Figure 33: Finished product — painted FDM part.

9.2. Optional items:

- Spray gun & ventilated spray booth.
- Finishing Touch Smoothing Station.

9.3. Sources:

- Automotive supply retailers.
- Paint supply retailers.
- Hobby shops.
- Hardware stores.

10. Recap - Critical Success Factors

10.1. Surface preparation.

- Start with smooth surfaces.
 - Orientation.
 - Slice selection.
 - Enhanced mode.
- Smooth, paint-ready surfaces.
 - Sand and fill to eliminate all imperfections.
- Thoroughly wash part.
 - Must remove all of the soluble support solution.
 - Degreaser for good adhesion.

10.2. Priming and painting.

- Multiple thin coats.
- Light sanding between coats.

10.3. Check compatibility of all materials.

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CONTACT

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