Designing for Optimal FDM Surface Finish

Overview

FDM® technology is increasingly used to create final production parts, particularly in the aerospace and automotive industries. The durable but lightweight nature of FDM materials make them well-suited for industrial applications, and the FDM design process is ideal for applications that require custom part designs.

However, a barrier preventing the adoption of FDM for some production parts is its surface finish. Due to the nature of additive manufacturing, parts produced with FDM have visible build lines and surface inconsistencies. This is acceptable for most applications, but is undesirable for parts that require a smoother and/or more aesthetic finish. However, techniques are available to mitigate this surface roughness. These techniques optimize the appearance of parts and allow companies to use FDM technology to its maximum potential.

Application Outline

With FDM technology, the finishing process begins with the design. Design best practices are available to provide the best starting point for an optimized surface finish.

Part orientation: A vertical build orientation can often improve overall surface finish, minimizing the appearance of uneven layer lines. Generally, orientations optimized for speed will sacrifice surface quality and/or part strength. Build orientations optimized for surface quality, while they may take longer to print, require less post-processing and thus significantly less manual labor.

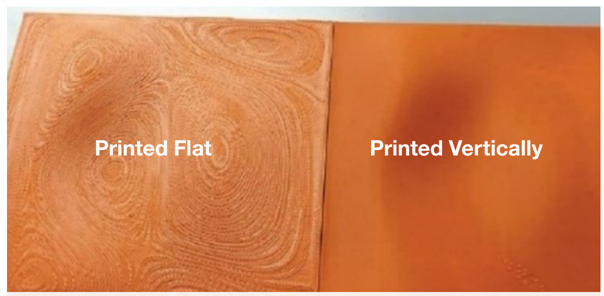
Self-supporting features: Some high-performance FDM materials, such as ULTEM™ 9085 resin, are incompatible with soluble support material and require breakaway support. However, this can significantly compromise surface finish. Using self-supporting angles reduces the amount of support needed, mitigating any roughness or inconsistencies caused by breakaway material and reducing material cost in the process.

Image texturing: Various software packages make it simple to apply a textured image to the part design. These textures are not only customizable and make parts look unique, but greatly minimize the visual appearance of build lines or surface inconsistencies in the final part. This can reduce or eliminate post-processing, increasing efficiency.

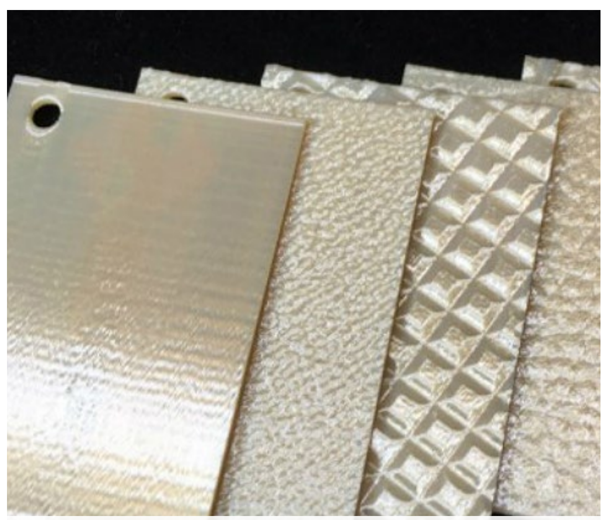
In addition to these design practices, post-processing applications can further improve the appearance and surface finish of a part.

Abrasion: Abrasion is a smoothing technique that involves the removal of a part's exterior layers in order to improve surface appearance. Common abrasion methods for FDM parts include sanding, media blasting, mass finishing, and vapor smoothing. In addition to smoothing, abrasion effectively prepares the part's surface for painting.

Surface Coating: Often used with abrasion, surface coating further smooths and adds color to the final part. Surface coating can be achieved through a variety of traditional methods, including painting, powder coating, and hydrographic films.



Demonstration of the difference in surface resolution between two identical geometries printed in the flat (or horizontal) and vertical orientations.



Examples of textures applied to FDM-created swatches.

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Example Application

This airline interior mock-up showcases the applicability of 3D printed FDM parts for aerospace. The FDM process provided the durability needed to produce functional prototypes for seat surround parts. However, these parts required a finished appearance close to how final production parts would look.

Everything except for the seat was 3D printed with ULTEM™ 9085 CG (certified grade) resin, and the parts comprising the display were finished with multiple techniques. For example, the front wall was left unfinished as an example of the raw capabilities of FDM technology and Stratasys thermoplastics.

Best design practices help minimize the amount of time required for post-processing. Several components were designed to optimize build orientation and support use. For example, the corner panels required a subtle curve in geometry. A horizontal build orientation, with the part flat on the build tray, would have yielded the fastest build time. However, this would have resulted in very extreme stair-stepping layer lines due to the curvature.

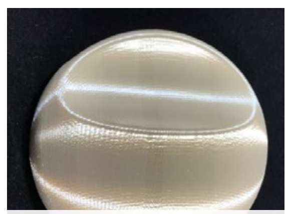
Instead, the corner panels were printed vertically, resulting in a much smoother surface that required minimal abrasion and surface coating. Although a vertical orientation means a longer print time, for certain geometries, the reduced post-processing means that the overall time to complete the part is still shorter.

Adding image texturing to a part before it is printed almost completely removes the need for post processing. Image texturing obscures build lines and imperfections, creating a smoother overall appearance.

These accent pieces shown on the right demonstrate the effect of applying an image texture before printing a part. Example A was not image textured, and as a result, build lines and some imperfections are visible. This part required full sanding and painting to obscure layer lines and create an even surface.

Example B was designed with image texturing, and has a much more uniform appearance even before painting. Additionally, this part only required slight “roughing” to prepare the surface for paint, and did not need to be fully sanded.

Example C depicting a leather-like texture is another example of how surface texturing can impact the appearance of FDM parts. Several components of the aircraft interior mock-up were designed with image texturing, including the walls. Like the armrest, these sections only needed to be roughed before painting and didn’t require a long sanding process. This is crucial especially for large parts like the wall in this display mock-up, which are more than six square feet each.



Example A: Accent piece without image texturing.

Example B: Accent piece with image texturing.

Example C: Painted accent piece with leather-like texture.

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