APPLICATION GUIDE:

Finishing Touch™ Smoothing Station: Expanding Possibilities

TIME REQUIRED ■□□ COST ■□□ SKILL LEVEL ■□□

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OVERVIEW

The range of additive fabrication applications is extensive and growing. As processes and materials have advanced, industry has expanded the use of the technology beyond prototyping to manufacturing. Although the applications are diverse, there is one dilemma they all share, an underlying trade-off between aesthetic quality and functionality. The additive fabrication technologies with the best surface finishes have been clearly distinguished from those technologies with the greatest strength.

Virtually any tough, durable and strong part can be finished to have a smooth, paint-ready surface. However, the cost and time to do so may be prohibitive, or the effects on part accuracy may be unacceptable. As a result, in the past companies may have elected to use a weaker, less durable alternative to save time, reduce cost and preserve feature details.

Finishing prototypes, tooling components or end-use parts can be done in several ways, each with varying impact on lead time, expense and quality. The most common alternative is to sand a part by hand (figure 1) or with power tools. Overall, this works well, especially for parts of reasonable size with few features and details. But when the part includes many features, small details or deep cavities, sanding becomes laborious, time consuming and costly. Another consideration is that removing material makes dimensional accuracy a variable that changes with each individual that touches the part.

Between sanding operations, parts may have filler or primer applied. This is a common technique when preparing a part for painting because it will deliver parts with very smooth finishes. Fillers and primers also help to preserves dimensional accuracy since depressions are filled before sanding them smooth. But this paint-ready finish comes at a cost. It takes much more time to apply multiple coats of fillers and primers and more labor to sand between each coat. This increases the lead time and the expense for the part.

Another method of smoothing parts that are made of thermoplastics is to "melt" the outer surface with a solvent. Parts may have MEK or ProWeld brushed onto their surfaces, or they can be dipped into a bath of the material. The solvent causes the plastic to liquefy, which fills in the low areas on the surface. The solvents have the added benefit of sealing a porous surface. Yet, there are some drawbacks. Small features may be distorted; cavities may not be reached; and drips will leave a visible mark. Another consideration is that drying times can be lengthy if the solvent must evaporate from deep within a porous surface.

Applies to Materials:

- ABS, ABSi, ABSplus, ABS-M30, ABS-M30

Supplies:

- Flow Formula M bicarbonate of soda (Armex: www.armex.com)
- DuPont-Vertrel SDG (www2.dupont.com/Vertrel/en_US)

Tools & Equipment:

- Finishing Touch Smoothing Station.

Figure 1: Hand sanding is one option for part finishing, but it may be prohibitive due to cost and time.

What industry needs, especially when pursuing direct digital manufacturing (DDM) applications, is a finishing technique that keeps lead times and costs to a minimum while delivering a robust, functional part with high accuracy and crisp feature details.

FDM AND THE SMOOTHING PROCESS

An alternative finishing method is now available for processing FDM parts. With little labor and a short processing cycle, the Finishing Touch™ Smoothing Station yields prototypes, tools and end-use parts that have finishes that are ready for paint, plating or production. The Smoothing Station can provide a surface finish of 32-63 microns.

The success of the smoothing process has prompted companies to re-evaluate FDM for applications that have used competitive technologies. In many cases, FDM was the preferred solution, but the time and expense to finish the parts was not suitable for the application. The Smoothing Station gives these companies the strength of FDM parts with the smooth surface finish that they need.

The Smoothing Station (figure 2) consists of two chambers: one for cooling and curing, the other for smoothing. Parts are first placed in the cooling chamber to reduce their temperatures. Then, they are transferred to the smoothing chamber for 10 to 30 seconds. The cooler temperature of the part causes the smoothing agent to condense evenly on all features. As it does, it sheets on the part's surfaces and smooths them to a fine finish. Let cure for 15-20 minutes. Lightly sand and repeat the cycle as necessary. Sanding is not required, but produces the best result. The cycle is repeated as necessary, and then the parts rest in the curing chamber. The parts are dry to the touch in 30-45 minuets. For best results, parts should be cured for 12-18 hours.

Figure 2: The Finishing Touch Smoothing Station produces paint-ready finishes with a quick, automated process.

When parts are removed from the Smoothing Station, they have a glossy finish (figure 3). If a matte finish is preferred the smoothing process is followed by burnishing with a bead blaster (sometimes called sand blasters). Stratasys recommends using a blaster with: no >30psi or 2.068 bar at the spray nozzle, envelope size 1016 x 509 x 508 mm (40 x 22 x 22 inches). Burnishing the surface with Polyhard Type III plastic bead media (order online at www.ustechnology.com/stratasys) gives the part a uniform, satin texture that is similar to injection molded parts.

Figure 3: An FDM part (left), after removal from the Smoothing Station (right)

The process is a gentle, no-touch method for finishing FDM parts. This protects small features from being distorted or mistakenly removed. It also preserves the dimensional accuracy of the FDM part.

This conclusion has been confirmed by studies performed at the University of Texas at El Paso's (UTEP) W.M. Keck Center for 3D Innovation. According to Frank Medina, W.M. Keck center manager, "The accuracy of the FDM 400mc is stated to be +/- 0.005 inch (+/- 0.013 mm). The smoothing process changes the part by no more than 0.0009 inch (0.023 mm). This allows us to conclude that changes in accuracy due to smoothing after three exposures are insignificant." In a separate investigation at UTEP, which was conducted by David Espain, Frank Medina, and Ryan Wicker, the team determined that dimensional accuracy is essentially unaffected by exposure duration or number of exposures. The team also determined that 1 hour, 20 minutes is sufficient for the part to be fully hardened after removal from the smoothing chamber.

The Smoothing Station reintroduces FDM to those applications where surface texture is as important as part functionality, lead time and cost. A typical batch of FDM parts can be processed and readied for painting in less than two hours with less than 15 minutes of labor.

APPLICATIONS

Examples of real-world applications of the smoothing process cover the entire spectrum from painted marketing samples to finished goods manufacturing. Since launching the Smoothing Station, usage of Fortus systems for a range of applications has expanded. With the smoothing process, companies are extending their use of FDM into applications that demand both functionality and smooth surfaces. Applications include: 1. Finishing master parts by painting or electroplating; 2. Tooling masters; 3. Sealing parts for liquid applications; 4. Thermoforming molds; and 5. Investment casting.

PAINTING:

A leading automobile manufacturer estimates that it takes three days and $700.00 to prepare a prototype front-end grill for painting. Over the course of three days, workers apply body filler, sand all surfaces, spray on primer, re-sand all surfaces and finish with a top coat of primer. In stark contrast, the same grill is smoothed and ready for paint in less than two hours. Total labor for the smoothing process is only ¾ hour, and supplies costs less than $10.00. While a 90 percent savings in time and expense is impressive, the company found that the biggest benefit was in build time reduction.

To minimize the time to hand sand a grill, the automotive company would build the FDM part in the same orientation that it is mounted on a car. It would also construct the part with smaller slice thicknesses. Smoothing eliminates both of these time consuming measures. By building the grill on its back with thicker slices, the company reduced build times by more than half. This decreased part cost, accelerated delivery, and increased machine capacity. Having more capacity and shorter lead times then resulted in less outsourcing, which further reduced prototype expenses while keeping sensitive, confidential design information within the organization.

AUTOMOTIVE GRILL

PROCESS	LEAD TIME	LABOR COST	SUPPLIES COST
Hand Sanding	3 days	$600	$10
Smoothing	2 hours	$40	$10
Savings	Time reduction with smoothing: 92%	Cost reduction with smoothing: 93%	

A leading manufacturer of children's toys and baby gear estimates that it paints nearly half of all additive fabrication parts that it makes in a year. To prepare these parts for paint, they are sanded, filled, sprayed with a primer coat and sanded once again. This approach extends lead times, consumes manpower and adds significant costs to the prototyping operation.

In an evaluation, the company compared the hand finishing approach with the smoothing process for preparation of an infant seat for painting. It discovered that it could reduce lead time and cost by more than 80 percent. While the smoothing process was completed in under two hours for less than $40.00, sanding and priming required six hours of labor and cost more than $250.00.

INFANT SEAT

PROCESS	LEAD TIME	LABOR COST	SUPPLIES COST
Hand Sanding	1.5 days	$240	$15
Smoothing	2 hours	$30	$10
Savings	Time reduction with smoothing: 83%	Cost reduction with smoothing: 84%	

THERMOFORMING:

A manufacturer of food packaging has used FDM tools for its thermoforming process when it conducts design validations. The advantage of an FDM tool is that it can be built porous, which allows a vacuum to be drawn through the entire part. This allows the company to use the FDM tools as soon as the build is complete. However, it did not use these tools for marketing samples because the porous surface was too rough.

Experimentation has demonstrated that the smoothing process allows the FDM mold to be dual purpose. Following the design verification, the FDM mold is smoothed. The glossy finish that results is ideal for the thermoformed marketing samples. With the smoothing process, the company can now thermoform design models and marketing samples in the same day (figure 4).

The one small limitation of the smoothing process is that is seals the surface of the part, which negates an advantage of an FDM thermoforming mold. However, the company discovered that it can simply pierce the skin of the FDM part in strategic locations. Since the smoothing process only penetrates 0.010 inch (0.25 mm), technicians can use any sharp-point tool to perforate the mold's surface.

Figure 4: An FDM smoothed mold is ideal for thermoforming packages for design validation.

ELECTROPLATING:

Electroplaters have found that the smoothing process performs two essential functions in one operation. The result is faster delivery, lower expense and higher quality.

Prior to the electroplating process, parts must be smoothed and sealed. Rough surfaces are visible in the plated part, and porosity allows the electroplating solutions to leech into the interior. The traditional, manual processes used to smooth and seal parts add to lead times and direct labor expenses. They also introduce variances in part quality and accuracy.

Hand sanding parts to reach a level of smoothness suited for polished, metal surfaces is a time consuming process (figure 5). It also involves some craftsmanship that can lead to variations in part quality. Likewise, sealing parts with primer can result in inconsistencies in the application of the primer and conductive coatings. The alternative is to dip the parts in solvent, but this can damage small details. Dipping also requires a long drying cycle of one to two days.

In contrast, the smoothing process protects small features and fine details in electroplated parts while preserving dimensional consistency. And it does so while minimizing direct labor and processing time. In most cases, parts are ready for electroplating in under two hours.

Figure 5: Electroplated parts with a high polish require very smooth surfaces.

CASTING:

Sand casting and investment casting foundries have implemented FDM to accelerate the pattern-making and tool-making processes. The one remaining hurdle to shorter lead times for high-quality castings has been surface finishing. Because the quality of the casting is dependent on the quality of the pattern or tool, time and labor are invested in each FDM part to manually finish the surfaces.

For investment casting, hand finishing is a repetitive process since an FDM pattern is consumed for every metal casting (figure 6). Besides the impact on time and cost, hand working the patterns makes it difficult to maintain dimensional consistency from part-to-part. The smoothing process addresses all three issues simultaneously. In one batch, the Smoothing Station can process multiple FDM patterns in under an hour with only a few minutes of direct labor. Additionally, the smoothing action is the same across all parts, so there is consistency in the surface quality and dimensional accuracy of the parts.

Figure 6: The smoothing process eliminates the repetition and costly process of hand finishing FDM patterns (top) for investment castings (bottom).

Sand casting foundries use FDM patterns to produce core boxes, copes, drags and match plates that pack sand to make the casting tool. Foundries will also make these items directly from an Fortus system (figure 7), eliminating the need for patterns. Whether it is an FDM pattern or FDM tool, the smoothing process minimizes direct labor and lead time to deliver production sand castings.

Figure 7: Sand casting cores (center) are made from FDM core boxes (left, top center, right) with smooth surface finishes.

The advantages of the smoothing process really grows when producing complex sand castings, such as gear housings or steering knuckles. One foundry notes that complex parts may need dozens of sand cores—each made from a different core box— to reproduce internal passages and cavities. Hand finishing a dozen core boxes adds many days and countless labor hours. By substituting the smoothing process, the same work could be completed in a fraction of the time with very little direct labor. The bottom line for the foundry is an increase in production capacity with a reduction in lead time.

CONCLUSION

Companies are realizing impressive reductions in lead times and expenses when the Smoothing Station is used to finish and seal FDM parts. Independent of complexity and number of features, the Smoothing Station creates a paint-ready finish in a just a few hours, and it needs less than an hour of labor and $10.00 worth of supplies.

The Smoothing Station has essentially automated the FDM additive fabrication finishing process. It eliminates the time, labor and expense of sanding, filling and priming parts to achieve a smooth surface finish for production parts, prototype tools and painted samples. In doing so, the Smoothing Station has removed any trade-off between aesthetic quality and product functionality.

FDM PROCESS DESCRIPTION

Fortus 3D Production Systems are based on patented Stratasys FDM (Fused Deposition Modeling) technology. FDM is the industry's leading Additive Fabrication technology, and the only one that uses production grade thermoplastic materials to build the most durable parts direct from 3D data. Fortus systems use the widest range of advanced materials and mechanical properties so your parts can endure high heat, caustic chemicals, sterilization, high impact applications.

The FDM process dispenses two materials—one material to build the part and another material for a disposable support structure. The material is supplied from a roll of plastic filament on a spool. To produce a part, the filament is fed into an extrusion head and heated to a semi-liquid state. The head then extrudes the material and deposits it in layers as fine as 0.005 inch (0.127 mm) thick.

Unlike some Additive Fabrication processes, Fortus systems with FDM technology require no special facilities or ventilation and involve no harmful chemicals and by-products.

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