WHITE PAPER

Guide to SLS & MJF Automated Powder Removal with Innovative Fusillade Technology

Learn how to fully optimize your Additive Manufacturing workflow for powder-based print technologies with the F.A.S.T. post-printing system.

POSTPROCESS
Automated. Intelligent. Comprehensive.

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I. INTRODUCTION

Initially when we think of 3D printing, we imagine a strictly additive process stacking wafer-thin layers one by one. Each layer is either contributing to the end-use part or the support structure to maintain the build integrity throughout the printing process. However, there are many ways to skin a CAD file. Powder bed processes, both Multi Jet Fusion (MJF) and Selective Laser Sintering (SLS), start by heating nylon powder to an elevated temperature, then a recoating blade spreads thin layers of the powder, usually around 0.1mm thick, one at a time. After each layer is laid, a heat source sinters, or fuses, the part's cross-section, solidifying the material. Following each sintered cross-section, the build plate lowers similar to other additive processes to make way for the next layer of powder material.

This process repeats until the build is complete. Once finished, you will be looking at a container filled with powder and parts nested within. Before parts can be removed and handled, there is a cooling step required that may take up to 12 hours. At this point, it turns into a bit of a treasure hunt. This may seem tedious, however the majority of bulk loose powder can easily be brushed away.

There are a few key differentiators that add value and make this process unique. The first and possibly most impactful for users is that there are no support structures required. The bed of powder that is not sintered is compact enough that it will support the hardened build. There is no concern regarding optimal support structure design, allowing for great design freedom. The second clear advantage is the ability to nest your build in the Z direction. You can optimize your build space working in a third dimension. Part rotation and stacking becomes a handy cost and time-saving function. Lastly, the loose bulk powder can be reclaimed and reused. This minimizes build waste and saves money on material. Powder bed technology is also a solid option to maintain fine feature detail and create functional assemblies from a single print. In addition, the white nylon materials commonly used, PA11 and 12, are considered by many as end-use materials, ready for the customer. Other material options for SLS include a rubber-like TPA, as well as glass, carbon, and aluminum filled polyamides.

Some drawbacks include the initial matte, grainy surface finish. For some users this is a non-issue. For those that need to improve the finish, it can be addressed in the post-print phase, but of course this requires additional processing. Another minor deterrent may be the limited color options. Although there are a couple of minor cons depending on your needs, it is clear that SLS and MJF provide some unique advantages where other additive processes are limited.

II. WHERE TRADITIONAL POWDER REMOVAL CRUMBLES

It is true, powder bed technology eliminates the need for support structure design and removal. However, it is not without its post-print challenges. After brushing away the initial bulk powder (see Figure 1), a thin layer remains adhered, leaving the part caked with unusable powder.

Figure 1. Example of an SLS part after the majority of bulk powder is removed.

This creates a new problem where basic submersible support removal systems, relying heavily on chemical reactions or ultrasonics, are rendered useless. The powder removal aspect of post-processing powder parts typically involves a high pressure and flow system combined with an abrasive component. Initially, some users might try soap and water, electric toothbrushes, water picks, or even a dishwasher. When that falls short and makes a mess, the more common technique is using traditional machinery and attempting a manual bead blasting effort. There are some clear drawbacks to this approach. The first limitation of bead blasting is simply being labor intensive. This process requires someone to stick their hands through clunky rubber gloves and peer through a limited window while they try to 'hose off' the part with high-pressure grit. As part geometries become more complex, and potentially more fragile, handling and blasting parts this way can lead to wide inconsistencies or even breakage. Beyond being labor intensive, the dry nature of bead blasting struggles to fully remove powder from fine cavities. This is quite the roadblock for many users wishing to print functional assemblies.

Another approach considered to address the removal of this pesky layer of powder is a vibratory system. The idea here is to aggressively shake and scrape off this final powder layer. However, this process runs into the same issues as bead blasting; you will not be able to remove the powder from smaller crevices. This uncontrolled approach, especially when using traditional vibratory equipment, also runs a high risk of damaging parts, or at minimum wearing down fine features before the powder layer is fully removed. This approach is also limited when trying to remove the partially sintered hybrid layer because it cannot reach small crevices for a uniform surface finish.

The bottom line is that these approaches are not practical if you want to fully leverage the powder bed printer capabilities.

III. PRESS PLAY AND REMOVE POWDER F.A.S.T.

Taking full advantage of your polymer printer requires removing the post-processing bottleneck, especially as your organization's additive manufacturing operation scales in volume. An ideal solution would free up operator time and provide repeatable results on multiple parts simultaneously, without damaging them. To tackle those needs, PostProcess Technologies developed the Hybrid DECI Duo, which has become the recommended automated solution for powder removal. Powered by PostProcess' AUTOMAT3D™ software, this intelligent, patent-pending system leverages Thermal Atomized Fusillade (TAF) technology. Two perpendicular, single-axis jet streams comprised of compressed air, proprietary detergent, and suspended solids provide targeted blast sequences while utilizing 360° part rotation for maximum surface exposure.

Breaking down the TAF technology provides some more insight:

Thermal: Leveraging heat when necessary to operate in temperature ranges for optimal Mechanical Rate of Removal (mRoR).

Atomized: Utilizing a slurry reduced to fine particles to address small cavities.

Fusillade: Firing a sequence of controlled blasts, either simultaneously or in rapid succession.

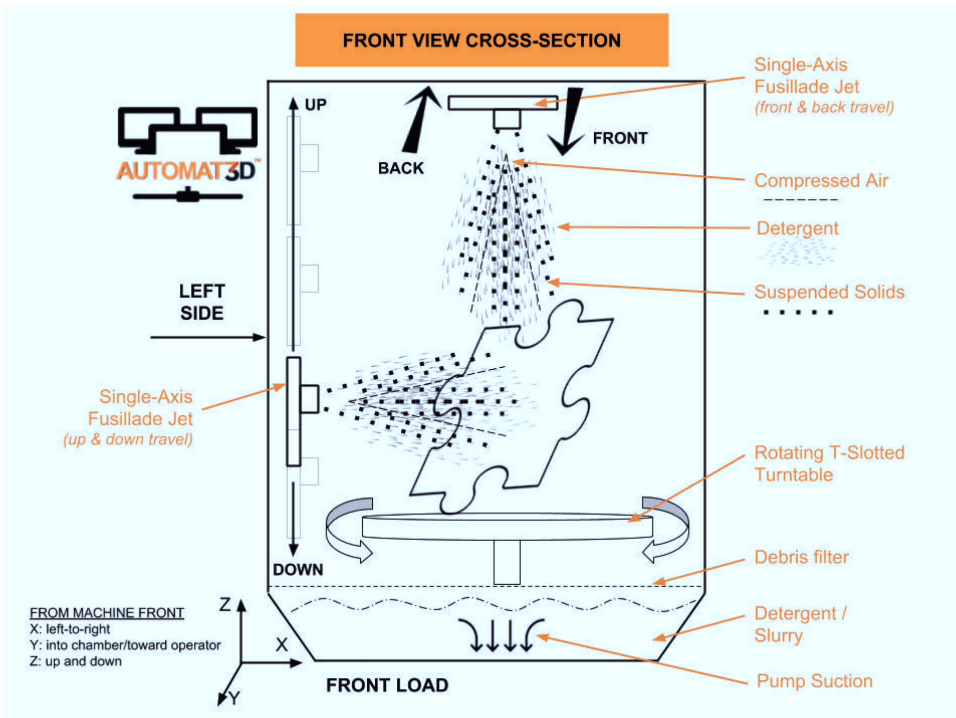

Figure 3. Simplified schematic of DECI Duo chamber.

Figure 3 is a simplified schematic of the DECI Duo's part chamber to further highlight some of the key features. The pressure of the compressed air can be regulated between 0 and 100 PSI, thus controlling the abrasive slurry to address both robust and fragile parts alike. The single-axis fusillade jets can be set to stay fixed in a particular location, or travel between two boundaries along the axis to optimize contact with the part. Combined with the rotating turntable, the Duo optimizes surface coverage with minimal operator attendance.

Machine settings and setup

The DECI Duo is offered with two standard fixture styles. The first is a basket style fixture up to 15" diameter and 12" high. The basket is secured to the t-slotted machine platform and allows for batch depowdering. Multiple parts can be put freely into the enclosed basket fixture, and the agitation sequence of the DECI Duo allows for even and complete powder removal. The second style is a vice fixture, also secured by t-slots. This is recommended for individual part processing, for higher precision or for extremely delicate parts. In addition, for higher volume production of powder bed printed parts, custom fixture design support is an option.

For optimum results with nylon powder removal, a zirconium oxide (ZrO2) media is used in the DECI Duo. The zirconia-based bead provides consistent results, even as powder collects in the system. For efficient powder removal of SLS parts, pump percentages of 80-100% and air percentages of 0-30% are recommended. These values are geometry dependent and can vary slightly from application to application. Deeper cavities, fine channels, and slots could all require higher air and liquid pressures. When programming nozzle movement, it helps to set nozzle bounds just slightly past the edge of the part(s) for total coverage. Some of the settings will vary if using MJF, but here is a summary of some recommended SLS settings showing a glimpse of the DECI Duo's control and versatility:

Settings:	
Media:	ZB-CBM
Water Percentage:	80%-100% (geometry dependent)
Air Percentage:	0%-30% (geometry dependent)
Nozzle travel bounds:	10-15mm beyond part ends

De-powdering process

Once the machine is set up to your desired parameters and parts are loaded, processing is as easy as pressing "Play". Processing times can take as little as 2 minutes up to 20 minutes depending on the powder volume, fixture type, and the number of parts per batch. Using both nozzles generally decreases process cycle time. For best batch processing, using the top nozzle 100% of the time and the side nozzle 50-80% of the time is ideal. Additionally, turntable rotation assists in lowering overall processing time and uniformity across the part.

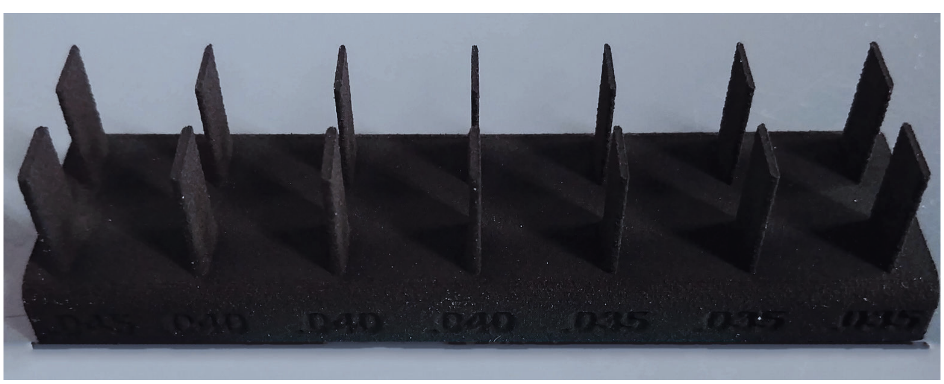

Figure 4: SLS printed part - 1 minute to remove adhered powder layer in the DECI Duo.

Once the depowdering process has been completed, the parts will be rinsed by the clean-in-place (CIP) nozzles. The system isolates the media and cycles only the aqueous solution to rinse the chamber, ensuring all powder is collected and removed from the air. Minor operator intervention is recommended such as rinsing the parts briefly outside the machine and drying using compressed air. Of course, this can be done once the next batch of parts is being processed. The operator will remain safe as the Duo is compliant with all OSHA regulations fixed with an emergency stop, light curtain, and stack lights showing machine status for the work floor.

For those who want to take their part appearance further, the TAF technology is also capable of addressing surface finishing requirements. In some instances, this may require swapping out media, but running the actual cycle is again as simple as pressing ‘Play’ on a different pre-programmed recipe.

Another way to summarize the DECI Duo is F.A.S.T.:

Focused: geometry-considerate controls
Accelerated: dramatically reducing cycle times
Suspended: optimizing suspended solids for both support removal and surface finishing
Transformative: revolutionizing the AM workflow in one system

After the work is done, powder removal clean up can be a messy process. The DECI Duo has an automated Media Separation Sequence (MSS) to address this issue. A filtration basket is placed on the turntable to capture the waste for easy disposal of the solids. For optimal performance, it is recommended to run the MSS at least once for every 10 lbs of powder cleaned in the system, or every two months, whichever comes first. With the AUTOMAT3D software, the user is reminded of this task along with other preventative maintenance alerts.

Figure 5: AUTOMAT3D software screen

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