APPLICATION BRIEF

High Density Vertical Stacked Printing for Figure 4 Industrial 3D Printing

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3D SYSTEMS
Additive Manufacturing Solutions

Introduction

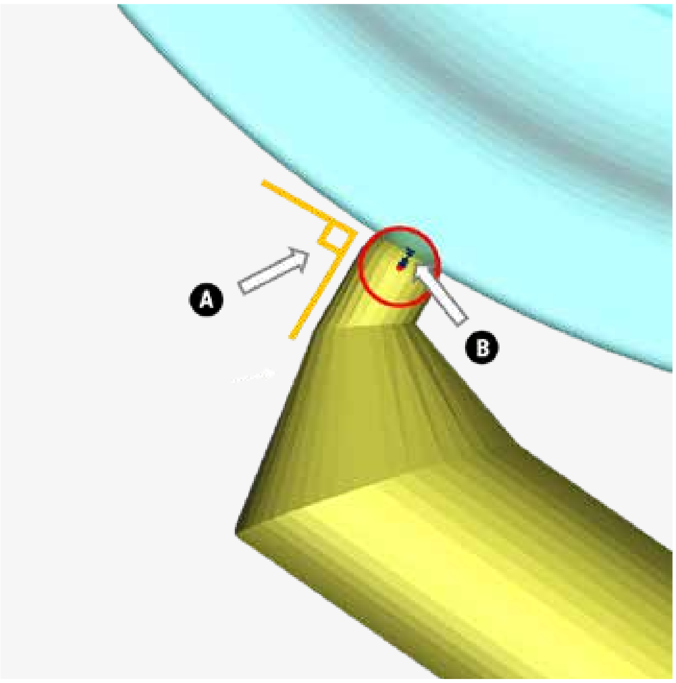
Additive manufacturing (AM) is transitioning from a primarily prototyping tool to scaled manufacturing. New materials are being developed with impressive properties for application-specific use cases across industries. Printers are getting larger, faster, and more precise with software tied in to provide more advanced features, capabilities, and workflows. While traditional manufacturing methods like injection molding still present a more affordable cost model at higher quantities, additive manufacturing offers greater supply chain flexibility, and a strong solution for low-volume and bridge manufacturing, as well as mass customization.

With the advance of production-capable 3D printed photopolymer materials and greater overall 3D printer workflow productivity, the opportunity has arisen to produce parts more efficiently on 3D Systems' Figure 4® family of 3D printers and challenge traditional methods. A significant boost in build efficiency can be achieved through high density part stacking – utilizing the Figure 4's printer build height, efficient nesting, and an optimized support structure to enable greater levels of batch printing and post-processing.

Advantages of High Density Vertical Stacked Printing over Traditional Methods

3D printing often leads to fast turnaround times without using expensive tooling. As such, AM serves as a great tool for prototyping and low/mid-sized production by using high density vertical stacked printing. Key drivers for stacked printing include:

- **Productivity and Efficiency:** By utilizing the full build height (350 mm) and stacking parts, more parts can be printed. With 3D Systems' additive manufacturing workflow software, 3D Sprint®, stacks can be easily generated and supported to maximize packing density, reduce post-processing, and decrease labor times.
- **Strut Array Generation:** Quickly generate and replicate strut supports throughout a stack within 3D Sprint. The open, sparse strut network maximizes solvent washing, air drying, and post-cure process effectiveness for batch manufacturing.
- **Overnight Printing and Cadence:** For manufacturers that do not work around the clock, there is a lot of wasted time at night that could be used for printing parts. Prints can be planned more efficiently to improve throughput in a single day by printing less frequently, but with a larger yield. If build times are too short, technicians would get overwhelmed from replacing builds for many printers.
- **Automation Compatible:** Another method for improving efficiency of the entire workflow is by using automation. With pinpoint contact strut supports allowing for quick removal of supports, automation can be used to clean, dry, and cure stacks of parts without human labor. Multiple wash stations can be used for cleaning parts.



Struts

Struts are sprue-like supports that are manually placed through point-to-point selection in 3D Sprint. Some features include:

- A perpendicular contact surface (A)
- An offset to create a notch for easy break-off (B)
- A spherical tip

Although struts are generated manually by the user, with stacking in 3D Sprint, struts are automatically replicated after they are generated for a single part and its neighbors. Struts also generate less heat during printing and have more lateral strength than normal supports. In addition, struts can be used between columns like trusses to create a rigid stack and are sparser than normal supports which will maximize solvent wash, air, and light process effectiveness for batch manufacturing. Strut supports are a lot easier to remove and scarring is minimal and consistent, which enables compatibility with automation of support removal strategies. This can also decrease labor times in workflows and lower part costs.

Design for Additive Manufacturing (DfAM)

To get the most out of additive manufacturing, it is important to design for additive manufacturing. Keep the bigger picture in mind as you go and ask yourself if and how components could be integrated, oriented, and supported. The results could lead to reduced assembly, increased performance, faster print times, reduced post-processing, and more. If you are new to AM design, take advantage of design reviews by 3D Systems' AM experts. 3D Systems' global Application Innovation Group (AIG) is comprised of application engineers with industry-specific AM experience. Tapping into their expertise early will help you flatten your own learning curve in additive and fast-track your project by avoiding late stage revisions.

Part geometry is also important in determining how to create the supports for stacking. For simple geometries, 3D Sprint smart supports will get the job done. They are quick and easy, although support scarring on top of parts might be harder to control.

For more complicated geometries or parts that have critical features like the examples below, struts are the recommended option. The washer-fitting stack on the left was designed for additive manufacturing and has many self-supporting features, reducing the amount of supports and struts needed. For the automotive vent clip stack in the middle and the controller housing stack on the right, struts are connected together in a tree-like structure to reduce struts, material usage, and to make it easier to clean.

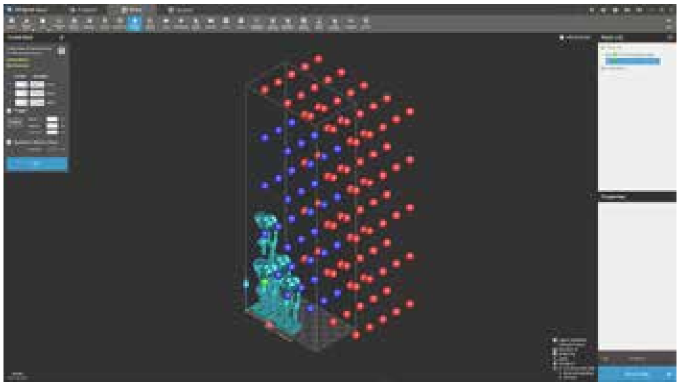
Workflow Solution & Best Practices

1. File Preparation

Proper file preparation takes both the print process and post-processing into account. Remember that there may be limitations for certain geometries and to plan accordingly. For example, avoid printing parts that have trapped volumes, as they act as a suction cup on the membrane, or large cross-sectional areas due to differential shrink or growth. Often a design change is preferable to extensive file preparation, particularly for larger production quantities.

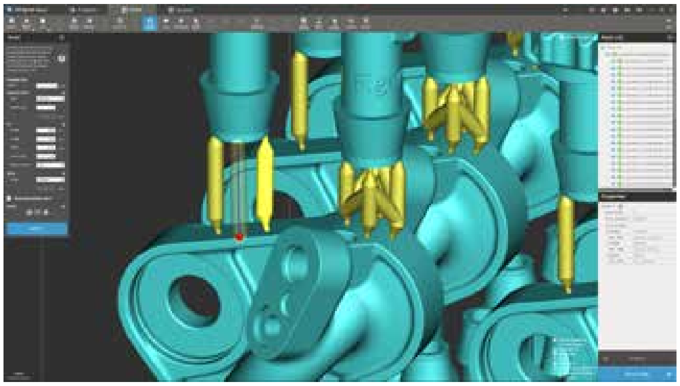
Two critical things to think about for file preparation are orientation and supports. It's important to determine what orientation would minimize supports, improve part density, and lower print speeds. It's also important to determine what the critical features are to avoid supports. More instructions can be found on our **Infocenter**.

To start this workflow, bring in the part you want to stack into 3D Sprint along with a base that is around the size of your part in X and Y. There are some generated bases to start with in 3D Sprint.



2. Create Stack

The next step is creating the stack of parts. You will have control over the size of your array along with some other features. It's easiest to put in larger numbers for your X/Y/Z count and drag the parts around to fit. What shows up as blue fits into the platform, anything in red is outside and will be ignored. Once the stack parameters have been defined, the stack will be automatically generated.



3. Create Struts

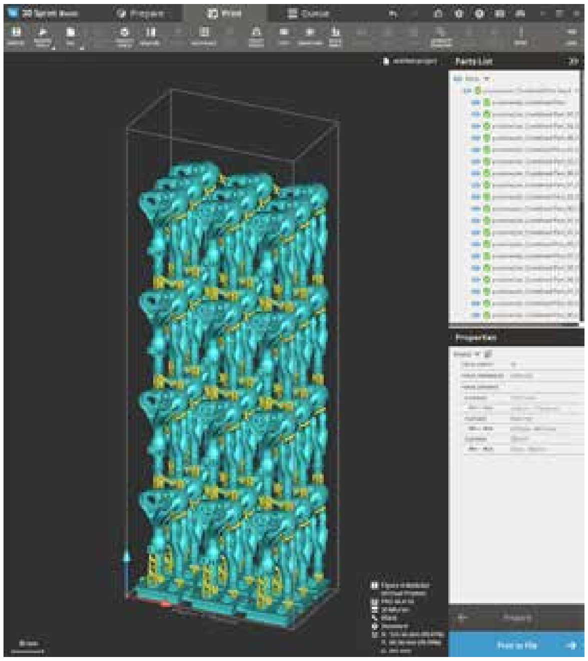
Default settings will provide a baseline for adequate removal and strength, but further optimization can improve strut removal for tougher or softer materials. Struts will be automatically replicated across the stack so struts only need to be drawn between the initial part and its neighbors.

For creating struts with secondary processes in mind, make sure to create struts between columns to improve the rigidity of the stack. The stronger the stack is, the more it can be handled for cleaning and post-curing. Make sure to adequately support bottom flat surfaces or re-orient them at an angle. You can also create struts on other struts and even create tree structures to minimize support usage.

4. Printing

Having a Figure 4 Modular helps with printing stacked builds because of its refill system. When printing stacks with a Figure 4 Standalone, make sure there is enough material in the resin tray. There are several things to check for to ensure the best part quality. They include checking for loose debris in the resin tray, mixing viscous materials and checking that the catch tray and print platform are clean.

When starting your first stacked print for a part, check your print for the first two rows to make sure your parts are adequately supported. Depending on the complexity of the part, it might take a few print attempts to fully optimize the process.



5. Post-Processing

For post-processing advice that is tailored to your application, we recommend working with an expert from our Application Innovation Group (AIG). In general, we recommend agitation in a solvent. Follow documented procedures for the material you are printing in. Usually a larger container will be needed to clean the entire stack, and a lot of labor time can be saved cleaning as a stack as opposed to one part at a time. We've seen the best results through breaking up the surface tension with an air-line and then dunking the stack in a large container of solvent.

We also strongly encourage capturing feedback from post-processing and using those insights to refine and improve aspects of part design or file preparation. This includes checking parts for trapped volumes, vent holes in one-way channels with no exit, and adding fillets for strength and ability to clean.

6. Solution Components

PRINTERS

- 3D Systems' Figure 4 Modular printer is the preferred solution to utilize industrial stacked printing at its maximum capacity
- 3D Systems' Figure 4 Standalone printer will also work with stacked printing

POST-PROCESSING

- Large buckets that are around 15 inches tall to dunk stacks into
- Figure 4 UV Curing Unit 350 to cure the entire stack

MATERIALS

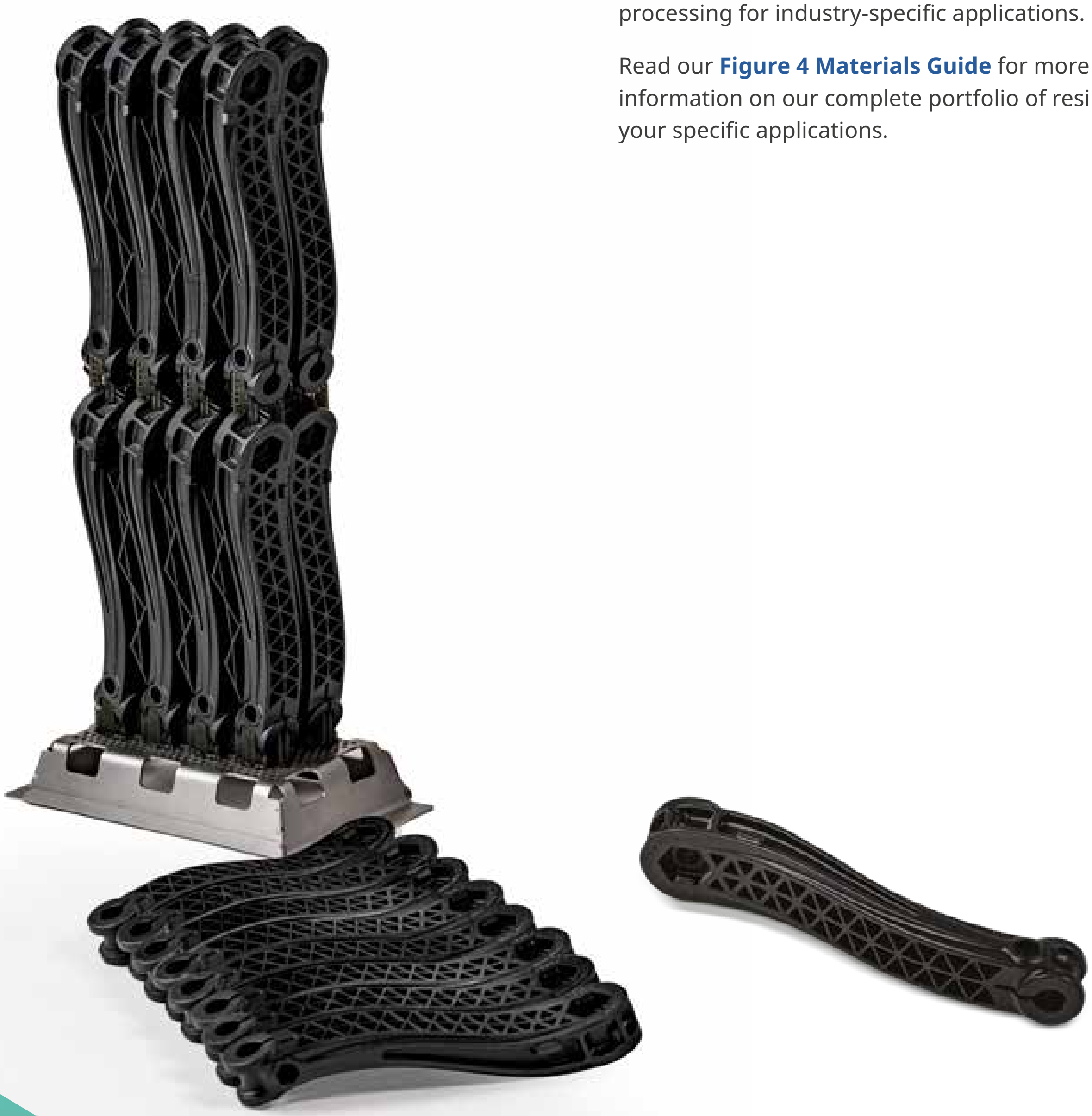
- All Figure 4 industrial materials

SOFTWARE

- 3D Sprint is 3D Systems' additive manufacturing workflow software, encompassing file preparation, stack and support creation, printing setup, and parameters

7. Critical Success Factors

- Strut placement and reinforcements can make the difference between a successful stack and a stack that falls apart during cleaning. Clever use of strut placement can reduce strut material usage and create an open space around the part for cleaning and curing.
- Orientation is another critical factor. With proper orientation, parts can be nested closer together and reduce the amount of supports scarring on your part.
- Material also plays a role in how stacks are oriented, nested, and supported. The more viscous or transparent the material is, the more spread out the parts should be.



Why 3D Systems

3D Systems offers a fully integrated productivity solution for additive manufacturing with plastics. We've configured the 5-step workflow process in 3D Sprint for creating industrial stacking with our Figure 4 technology and full portfolio of production-capable resins. Figure 4 technology is modular, offering scalable, batch-level productivity to enable continuous maximum height prints. Our photopolymers are engineered with material chemistry and long-term environmental stability for production applications across a range of industries. The batch-production process and workflow takes advantage of strut technology, by creating easy to place and easy to remove supports that result in minimal scarring with adjustable strut parameters for custom supports. It also enables automation for part removal from the stack. Our application experts have years of experience in additive manufacturing, including DfAM, workflows and post-processing for industry-specific applications.

Read our **Figure 4 Materials Guide** for more information on our complete portfolio of resins for your specific applications.

What's Next?

Learn More About Industrial Stacked Printing with Figure 4 for Greater Manufacturing Productivity.

Talk to Our Experts.

Contact us

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