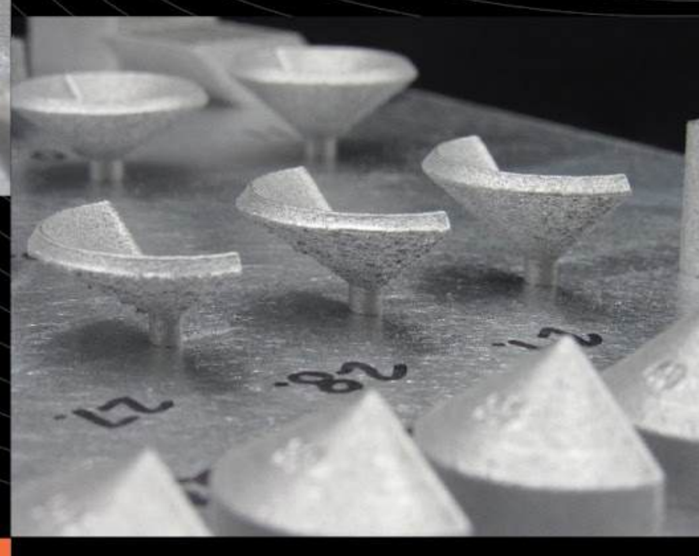
Dyndrite | ELEMENTUM 3D

CASE STUDY

Accelerating Material Design Studies, Parameter Development, and Support-Free Print Strategies in LPBF



Accelerating Material Design Studies, Parameter Development, and Support-Free Print Strategies in LPBF

Elementum 3D leverages Dyndrite LPBF Pro on an SLM 125 to dramatically accelerate experiments and improve parameter development of A2024-RAM2 Aluminum.

Overview

As metal additive manufacturing (AM) expands into critical production applications for rocketry, aerospace, performance automotive and defense, the ability to experiment, iterate and optimize geometry specific build layouts quickly and systemically have become a top priority. Historically, material parameter development, conducted via a Design of Experiment (DOE), has been a slow, manual, error prone, and expensive process.

To make matters worse, today there are limited methods of assigning parameters based on feature characteristics, beyond just downskins and upskins. While most conventional software allows basic differentiation, i.e. specifying one set of parameters for surfaces below a certain angle and another set for surfaces above a different angle, achieving greater control often requires splitting the part into multiple bodies, reassembling in build prep, and assigning different build parameters to each - a time-consuming and impractical task.

Dyndrite LPBF Pro redefines the metal manufacturing software landscape. It introduces tools that enable geometry-specific toolpath, fine control over laser parameters and automation of complex processes - allowing manufacturers to create repeatable and consistent production parts previously thought impossible.

Background

In AM, small features, thin walls, domes, and cantilevers pose significant challenges for engineers. Legacy strategies employ a 2.5D analysis methodology to look only above and below a target layer. This narrow view consistently overlooks feature definitions where better local strategies could be applied. Well known examples here include: (1) Support free printing at angles under 45° while retaining acceptable levels of surface finish and dimensional accuracy, (2) Printing of internal flow channels and (3) Printing of thin wall features.

Typically, unsupported overhangs at angles under 40° risk sagging or dross; traditionally, correcting this requires support structures to maintain integrity during printing. However, building supports changes print dynamics, including thermal properties, build times, and material consumption (see figure 1).

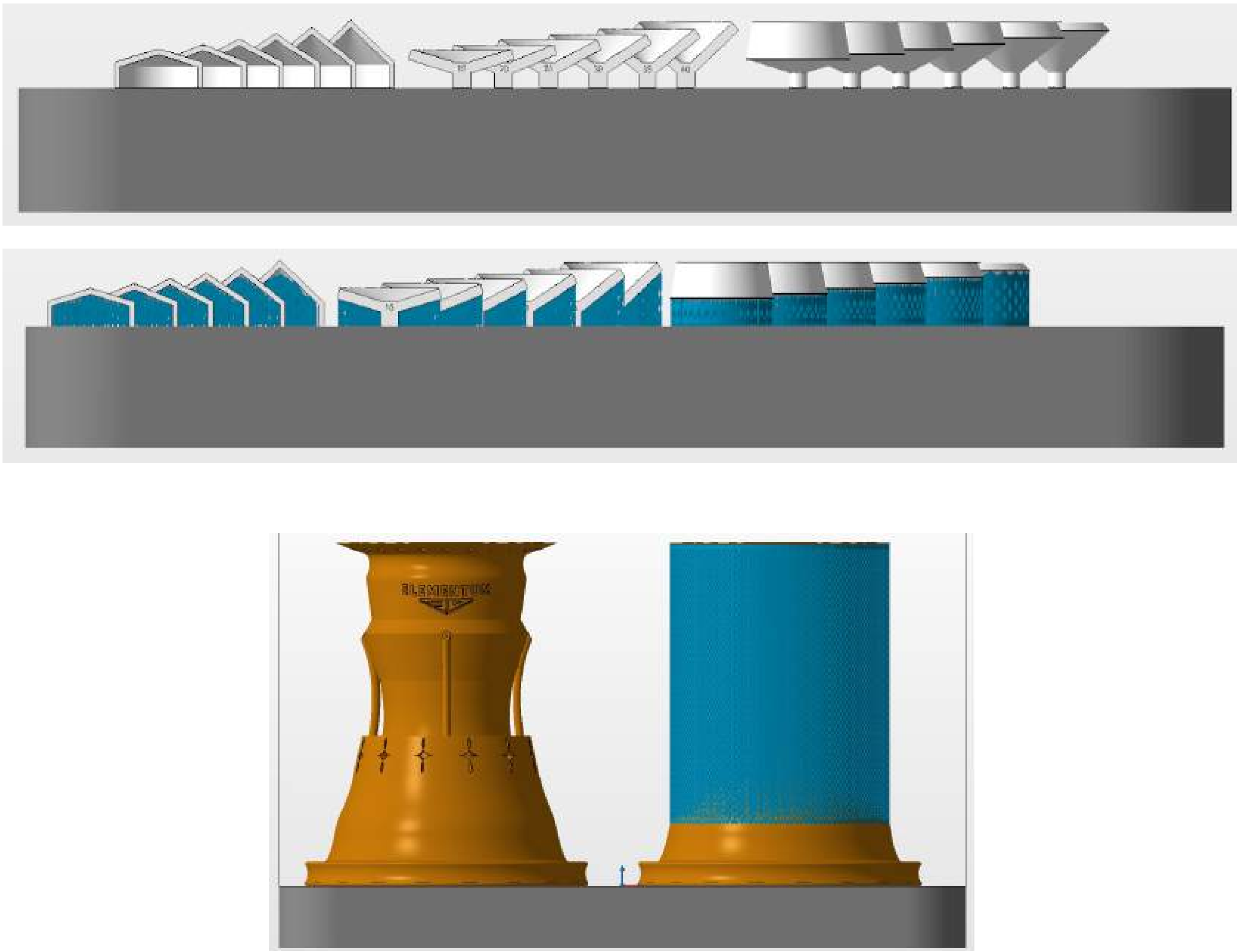


Figure 1: Parts with overhangs at angles under 40° traditionally require support structures, increasing build times, material usage and requiring post processing to remove.

Dyndrite LPBF Pro interrogates 3D geometry and enables the assignment of feature-specific parameters. This technique provides users with a powerful tool for both detecting difficult features as well as implementing parameters that match the part condition. This is particularly useful for developing parameters that optimally distribute input energy from an objects' surfaces into the bulk material to achieve better surface finish and quality, as well as potentially increasing productivity.

Used appropriately, such tools can also help reduce the requirement for support and post processing, reducing labor time in design and engineering, machine time, material waste and post processing, and significantly boosting overall equipment effectiveness (OEE).

Challenge

Elementum 3D, a leading developer of enhanced metal AM powders, seeks to provide customers with optimized parameter sets for its A2024-RAM2 advanced composite aluminum material on an SLM 280. The mission was to determine if angles below 30° could be delivered without the need for supports, with a stretch goal of achieving unsupported 15° overhangs with improved downskin surface finish.

Another objective was to reduce the time and effort required to craft these experiments. Using legacy build preparation software for experiments like this is an intensive process involving hours of data preparation, manual build layout, manual labeling, manual parameter assignment, et cetera. The end state and results being recorded by manual data entry or tedious copy/pasting, often leading to human errors, and requiring peer review. To make matters worse, each new experiment, or re-running of an experiment, requires starting over from scratch.

Solution

Dyndrite LPBF Pro software is an advanced AM toolpath development and automation solution enabling streamlined build preparation. The software allows for the manipulation and automation of all aspects of the build preparation process, including importing and positioning parts, labeling, creating supports, defining print layer thickness, hatching parameters, laser power, scan speed, exposure order and more. Moreover, Dyndrite's 3D Volumetric Segmentation feature enables users to interrogate their geometry, detecting differentiated regions where unique parameters can be assigned. This method, instead of the common 2.5D approach, means unique settings optimized for thin walls, overhangs, surface finish, machine variability, and so on can now exist within a single build, single part, single layer, or single feature.

Dyndrite LPBF Pro empowers users like Elementum 3D to automate DOE builds, repeatedly produce intricate prints, and have pinpoint control of parameter assignment. Dyndrite LPBF Pro offers both a graphical user interface (GUI) and an integrated Python interface. Unlike legacy software tools with add-on scripting capabilities, Dyndrite LPBF Pro's Python capabilities are intimately woven within the application, thus saving and codifying the knowledge of how to generate the build. Scripting facilitates fast and easy re-use, and acts as a foundation for further development or refinement as processes become more sophisticated. Dyndrite LPBF Pro also provides API calls that open up communication pathways to third party applications, such as messaging, production queue management, automated reports and more.

Single and multi-optic metal 3D printers from Aconity3D, EOS, Renishaw, SLM and other LPBF machines are supported. The software also supports open standards such as CLI and

3MF as well as being the first to support the Open Vector Format (OVF) from RWTH Aachen University Chair Digital Additive Production DAP, in cooperation with the Fraunhofer Institute for Laser Technology ILT, which offers even more capability.

Test Procedure

The experiments at Elementum 3D involved creating a build plate of common geometric features like: overhangs, thin walls, slanted thin walls, and spiral helices (see figure 1).

Figure 2a: Dyndrite LPBF Pro screenshot of build plate and slice viewer featuring range of geometry types, including overhangs, thin walls, slanted thin walls, and spiral helices

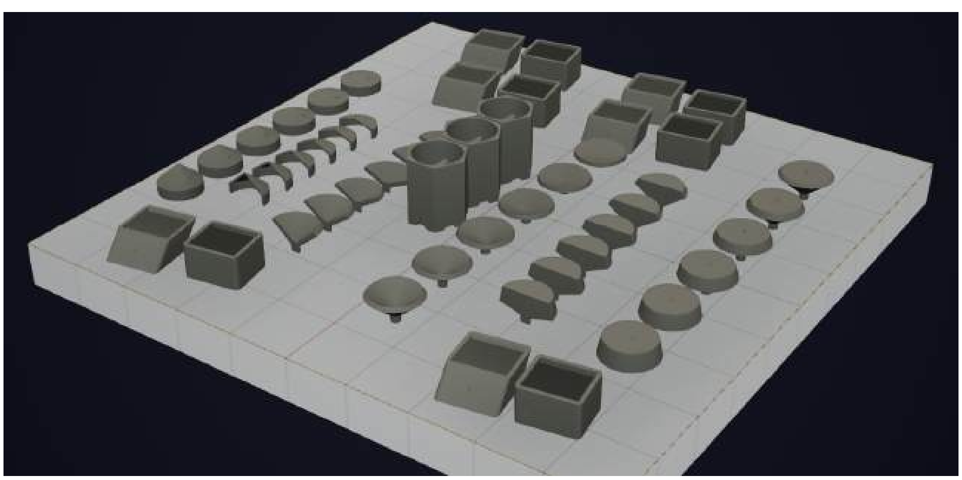


Figure 2b: Close up of Build plate within Dyndrite LPBF Pro

Each part on the plate was analyzed with Dyndrite's 3D Volumetric Segmentation to discretize regions of interest where unique laser parameters were assigned. (see figure 3)

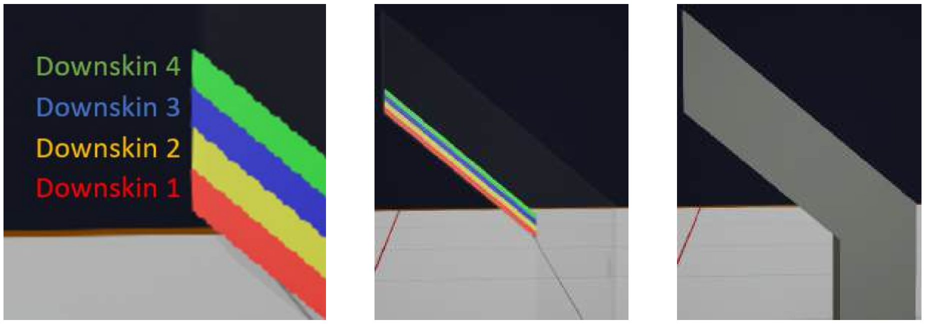


Figure 3 Dyndrite LPBF Pro 3D Volumetric Segmentation applied to overhang parts

To expedite the test, Elementum 3D's existing downskin print strategies were used as a baseline. Each test part was assigned a combination of parameters varying from the baseline, for laser power, scanning velocity, hatch style, exposure order, and layer thickness.

Experiment 1 was conducted using 12 test groups with a variety of overhangs between 10-40°, with 40µm layers. The parameter sets of the 4 best test groups were selected for further refinement.

Experiment 2 further dialed in the parameters, and contour scans were added to improve surface finish. The best resulting parameter set was further investigated.

Experiment 3 used an array of different geometries focused on thin wall features including a spiral helix with a 20° overhang, overhanging thick and thin features, and thin walls consisting of a single vector scan path with multiple passes.

Results

Experiment 1

As expected, only some test groups were successful. However, this test group was able to build support-free down to 15°, while three others were able to print to 20°. These are the groups selected for Experiment 2.

Experiment 2

Using more focused parameter sets and with the addition of contours, the team was able to print a majority of the parts at 15° with one or two failures due to recoater interaction. Downskin surfaces noticeably degrade at lower and lower angles.

Experiment 3

The best resulting parameter set from Experiment 2 was used for all parts and experienced no recoater interaction. Large flat surfaces were created down to 15°, and thin walls were printed without any porosity (see figure 3).

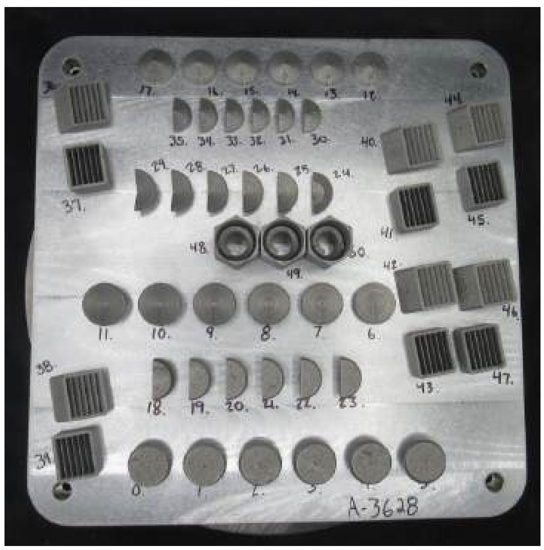
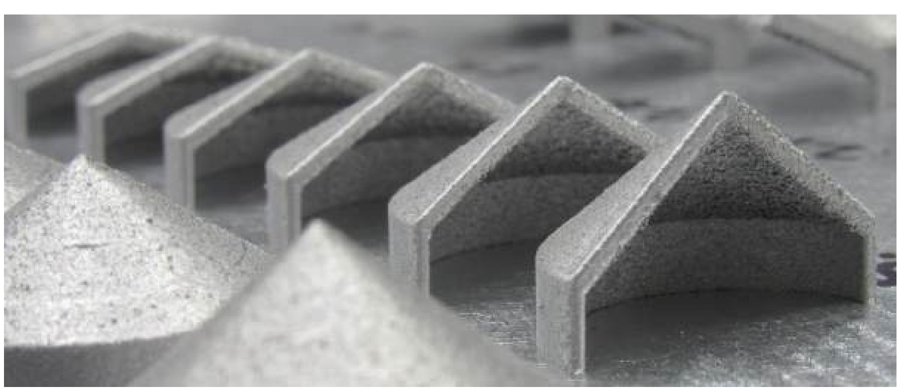


Figure 4: Experiment 3 printed build plate featuring support-free surfaces successfully printed down to 15°, and thin walls without any porosity.

Build Plate Close Ups



Close up: Concave support-free geometry

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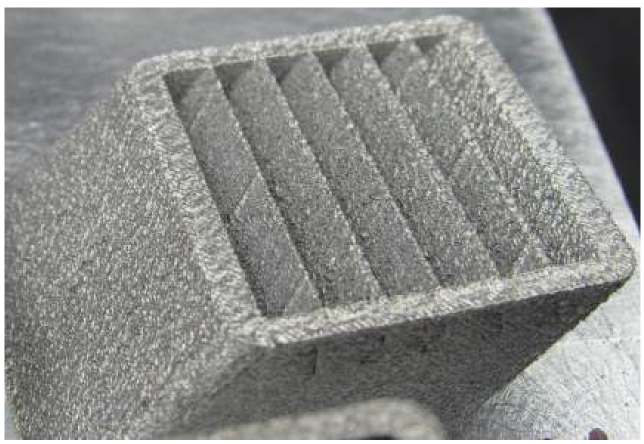
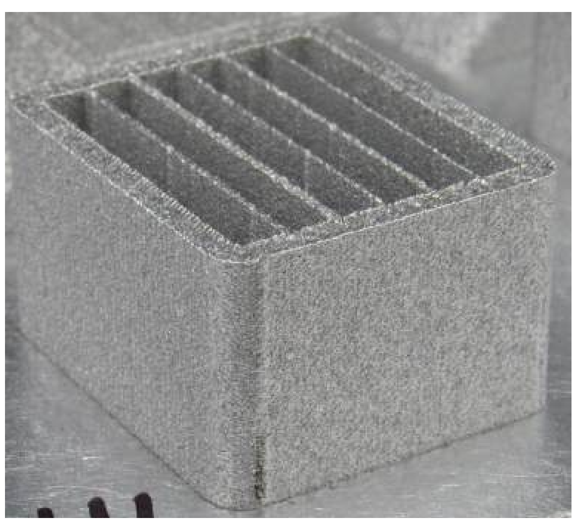
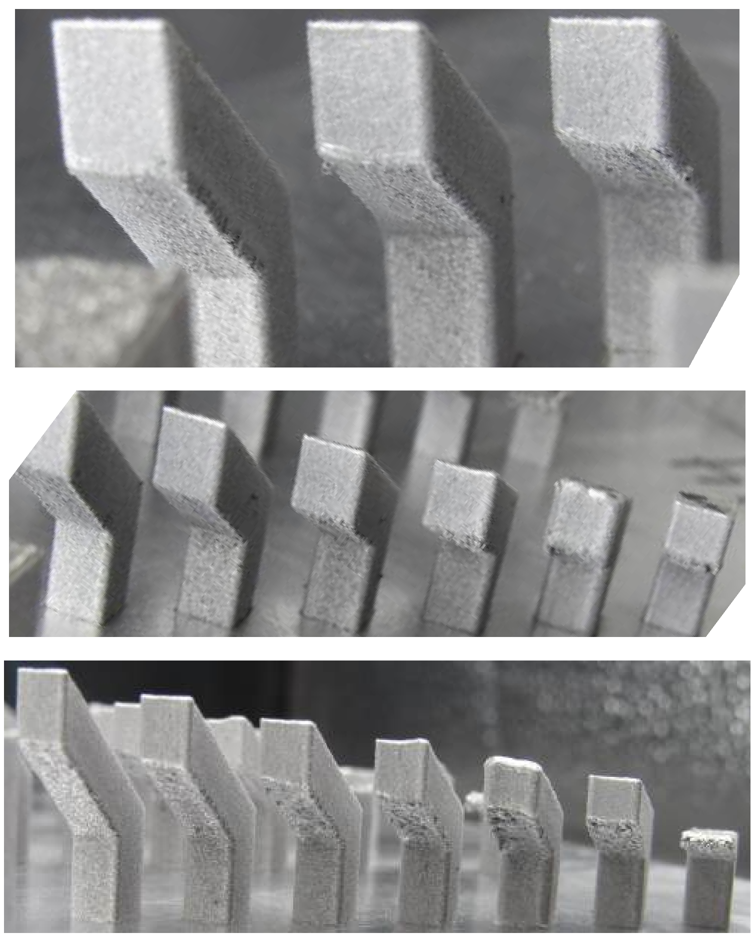


Close up: Slanted thin walls



Close up: Thin walls

Close up: Support-free spiral helix with 20° overhangs



Close up: Support-free overhaps going from 45°- 10° overhangs

Summary

Utilizing Dyndrite LPBF Pro Elementum 3D yielded several significant advantages, including:

- ➔ **Significant time savings in DOE setup** - Many hours eliminated in regard to part positioning, labeling, and parameter assignment. Further time saving was realized by automating subsequent builds (leveraging existing scripts).

- ➔ **Superior print parameters settings** over those previously defined for the material. Leading to the successful printing of overhangs of 15°, thin walls the thickness of a single vector scan path, and corkscrews with 20° overhangs.

- ➔ **The elimination of support structure** for parts down to 15°. Dyndrite parameters surpassed Elementum 3D's previous capability for supportless low angle features, saving print time, material, and post-processing time, while expanding the range of applications.

Dyndrite LPBF Pro enabled Elementum 3D to greatly enhance their existing materials parameters, including for support-free printing, expanding the applicability of their material within their industry (see figure 4).

Figure 5: Applications for Elementum 3D A2024-RAM2 High Strength Aluminum

Testimonials

“For us, Dyndrite’s LPBF tools have allowed us to increase geometric capability and print quality while dramatically reducing the time it takes to prepare builds. Parameter sets developed using Dyndrite surpassed our previous capability for supportless low angle features, thus expanding the range of applications favoring additive manufacturing. Dyndrite is helping Elementum 3D deliver a more effective product to our customers.”

Dr. Jeremy Iten
Chief Technology Officer | Elementum 3D

“Being able to quickly import different test coupons, label them, and assign different parameter sets on the fly, automatically, makes Dyndrite’s software a game-changer,” said Jared Rickaby, VP of Engineering Design, Elementum 3D. “Being able to do all of this quickly and without stress makes setting up Design of Experiment builds just that much easier, and allows us to save money by reducing the number of hours it usually takes to set all of this up manually, through a series of different software packages. With Dyndrite, we get to keep all of this within one software package.

“Dyndrite’s software just makes sense from a parameter development and research perspective, as well as from a production and build setup perspective.” Said Rickaby. “Dyndrite can be a tool for the engineer to use for saving a lot of time, money, and thought on build orientation, build setup, support generation, parameter assignment, and build export to equipment.

“We can continue pushing the boundaries of metal 3D printing with Dyndrite. Dyndrite is the key to unlocking increased productivity in many ways in our metal AM development process.”

Jared Rickaby
VP of Engineering Design | Elementum 3D

About Dyndrite

Dyndrite's mission is to fundamentally change how geometry is created, transformed and transmitted on a computer. Our Accelerated Computation Engine (ACE) is the world's first (geometry agnostic), multi-threaded, GPU-accelerated Geometry Engine. We create and license tools that give companies the power, freedom and control necessary to deliver on the potential of digital manufacturing.

Dyndrite LPBF Pro

Dyndrite LPBF Pro is the company's flagship application. It gives material, quality, process, and applications engineers unprecedented control and performance to solve their toughest geometry and compute challenges. It streamlines the print preparation process, provides users with previously unattainable part printing capabilities, accelerated build rates, and unprecedented productivity. The software aims to improve precision, traceability, and repeatability, simplifying complex processes and pushing the boundaries of metal additive manufacturing.

For more information visit: www.dyndrite.com.

About Elementum 3D

Elementum 3D is located in Erie, Colorado. We are an advanced additive manufacturing (AM) materials and parameters development company specializing in the commercialization and supply of groundbreaking high-performance 3D printed metal alloys, ceramics, refractories, and composites. Our goal is to radically expand the extremely limited metal AM materials library.