Dyndrite

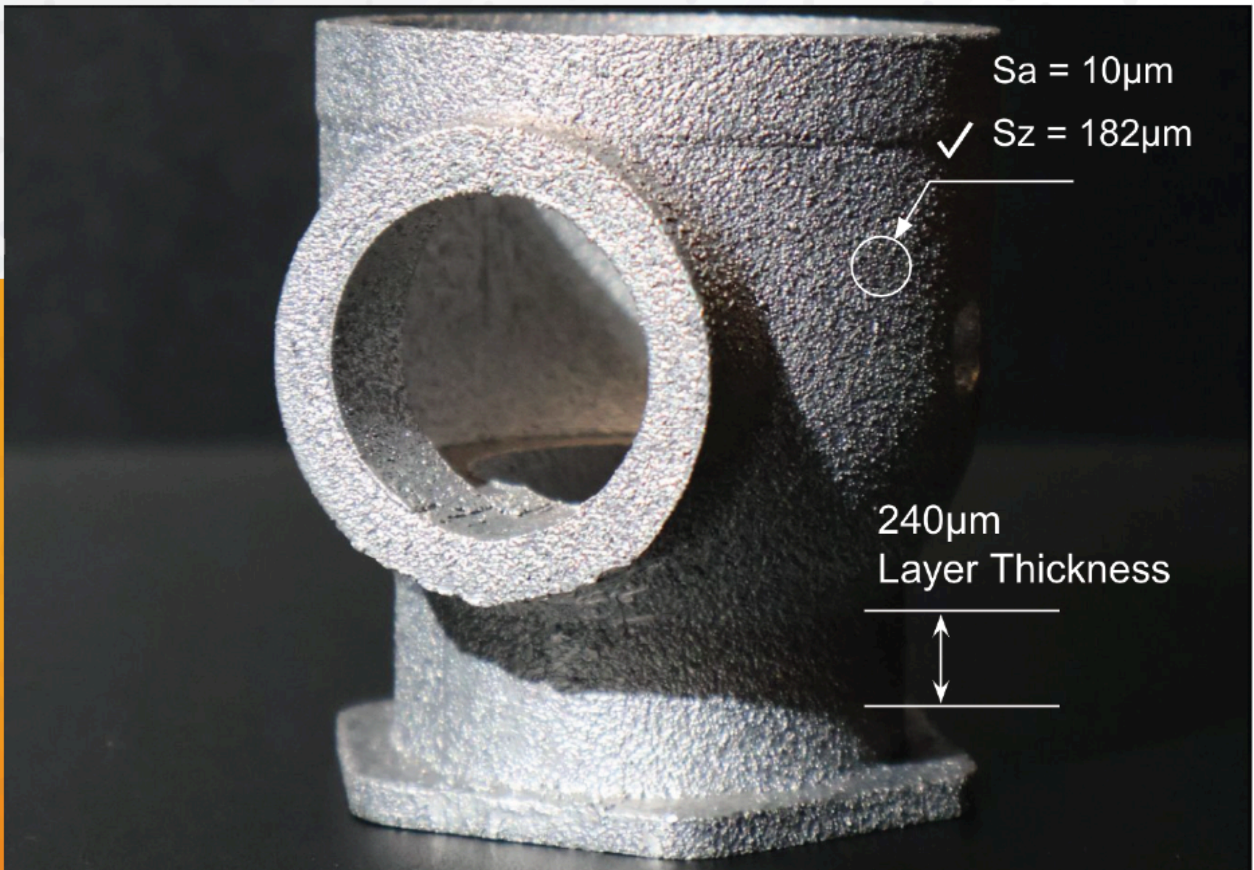
CASE STUDY

Faster Builds, Lower Cost, and Excellent Surface Finish — Who Says You Can't Have it All?

80% Lower Costs

7-9x Faster Times

100% Maintained Surface Finish



aconity3D equispheres

Faster Builds, Lower Cost, and Excellent Surface Finish—Who Says You Can’t Have it All?

Production-grade metal AM parts at 80% lower costs in 7-9x faster time, without sacrificing surface finish. Equispheres, Aconity3D and Dyndrite collaborate to create high productivity, improved surface quality metal AM parts that blow all existing benchmarks ‘out of the water’.

Overview

Since the fall of 2023, Equispheres, a leading producer of highly engineered metal AM powders, and Aconity3D, a developer of custom-tuned metal AM machines, have collaborated to explore the potential of combining laser beam shaping with ‘engineered’ metal additive manufacturing (AM) powders. This collaboration aims to boost productivity and reduce the cost of metal 3D printed parts. Initial results have shown an impressive reduction in print time; however, the rough surface quality of the parts required extensive post-processing, which offset some of the productivity gains and increased costs.

To address this final challenge, the team integrated Dyndrite LPBF Pro software into their workflow. This addition helped them deliver significantly improved surface finish - while maintaining the performance gains previously gained.

The Challenge

A well-known saying in manufacturing states “You can have speed, quality, or price—pick any two,” often attributed to James M. Wallace in the mid-1980s. This idea suggests that you can prioritize two of these factors, but you’ll have to sacrifice the third. For example, you can have high-quality parts produced quickly, but it will come at a premium. Conversely, you can opt for fast production at a low cost, but quality will suffer.

While this has been true for traditional manufacturing, it’s been especially relevant in metal additive manufacturing (AM), where the dilemma has been even more pronounced—almost to the point where the choice seems to be "Pick One." Moreover, low production speeds, inconsistent quality, and high costs regardless of quality have hindered the widespread adoption of metal AM.

This raises the question, how can these challenges be addressed? Is there a way for metal AM to live up to its full potential? Can we break this compromise and achieve speed, quality, and affordability all at once? Can we, in fact, have our cake and eat it too?

Solution

The companies began their research by integrating laser beam shaping technology with metal powders specifically engineered for LPBF 3D printing. Using legacy build preparation tools to configure each build, the initial results were impressive—producing high-quality parts at speeds 8 to 9 times faster than industry benchmarks and cutting costs by 80%. However, the project faced challenges with surface roughness, as the speedier process increased surface roughness substantially requiring additional post-processing time - reducing the overall efficiency gains.

The Lasers

LPBF machines conventionally utilize single-mode lasers with a Gaussian intensity profile (think of a bell curve with the highest energy concentrated at the center and tapering off towards the edges, as illustrated in Figure 1 below). This profile creates a sharp temperature peak in a small area, which slows down production when working on bulkier sections of a part. Since most of the energy is focused in the center of the beam, maintaining part quality often requires tighter spacing between each laser track. This increases the laser's time on each layer, leading to longer build times. When higher-powered lasers are introduced, the uneven energy distribution becomes more pronounced, causing greater irregularities in heating and melting that must be addressed. These challenges have traditionally limited the laser power in LPBF machines to approximately 1 kilowatt (kW).

However, by switching beam profiles from Gaussian/Single-mode to Multimode (Fig. 1), you can use either “top hat" or “flat top” or, if using an nLight AFX™, a “ring” shape, to better control the heat deposition into the part leading to more consistent powder melting. This means that laser power and scan speed can be increased, melting more layers and ultimately improving build rates.

For this initial study only Gaussian vs. flat top was compared.

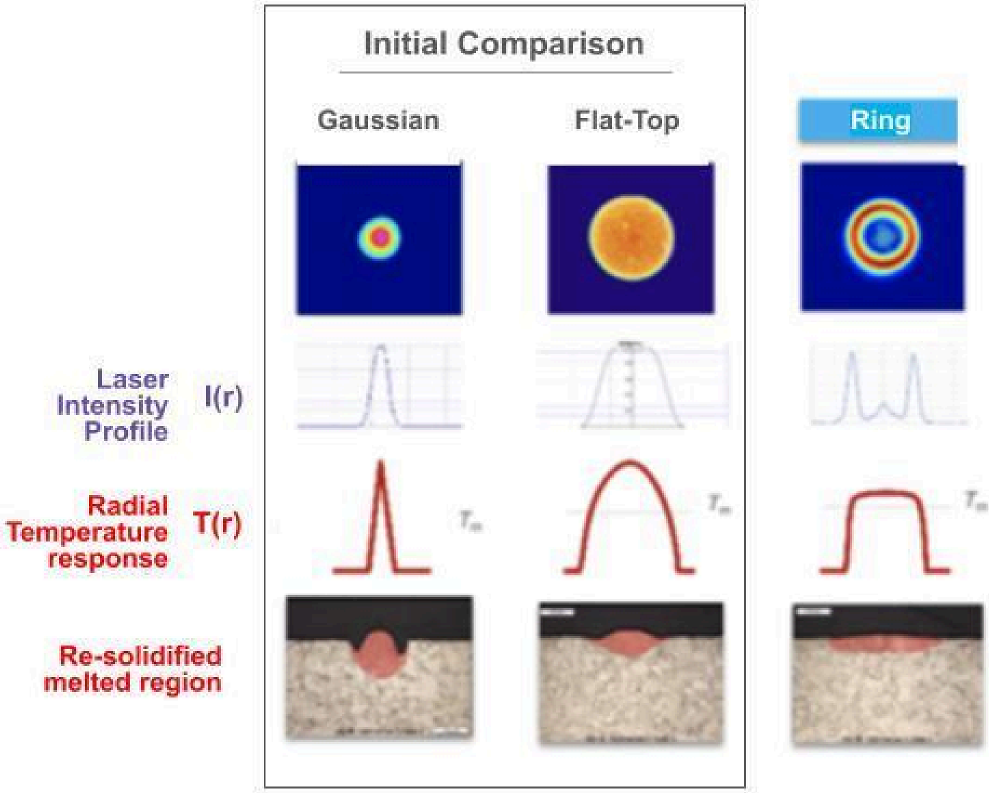


Figure 1: *The temperature profile in the melt pool and shape of the re-solidified material strongly depend on the laser beam shape. It should be noted, both a Gaussian and a flat-top beam leads to excessive heating within the center, resulting in a suboptimal track cross-section. In contrast, a ring-shaped profile creates a flat temperature distribution, leading to wide and flat track cross-sections. Comparing flat-top to various "ring" profiles will be the focus of a follow-on study.*

On an AconityMIDI+ metal 3D printer the team fit both a standard nLight gaussian laser which provides up to 1000W in single mode, as well as a YLR-3000/1000-AM laser by IPG Photonics to provide top-hat beam shaping modes during the build. The YLR-AM laser allows users to rapidly change beam spot size from single-mode to ~3-5× larger in diameter from the same laser without any bulk moving of external optics.

The Material

The team chose Equispheres NExP-1 line of AlSi10Mg powder which is specifically engineered for the LPBF process and boasts high layer thickness processing rates, enhanced melt pool stability and an overall consistent melting behavior. Equispheres NExP materials are created using a unique atomization technique that produces near-perfect spherical powder. Its uniform size, sphericity, and consistent microstructure — as well as smoother surface and thinner oxide layer — result in more rapidly manufactured metal parts with excellent mechanical properties, even at high layer thickness melt pools.

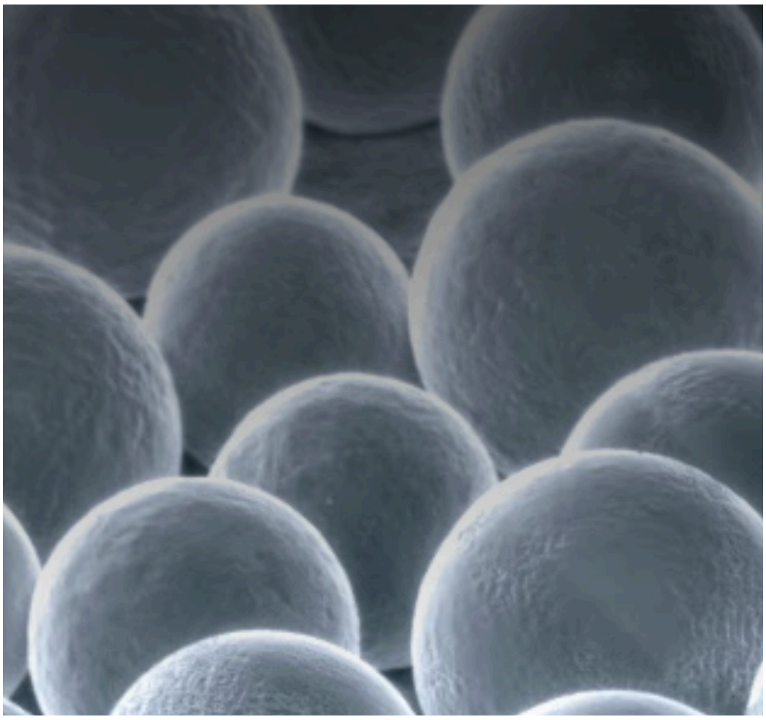
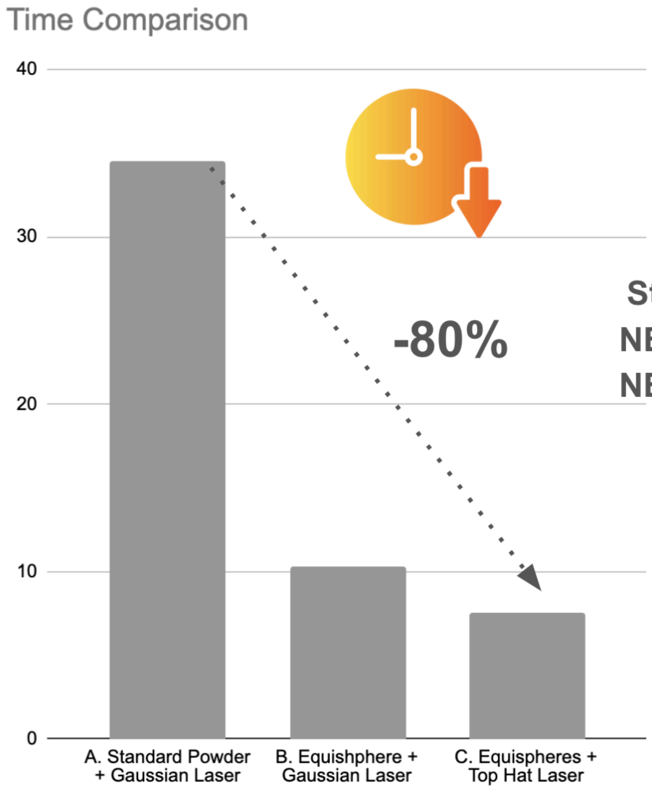


Figure 2: *Close-up of the Equispheres NExP-1 powder. NExP-1 has been designed for volume part producers where productivity is a priority. It provides exceptionally fast build speeds and can be rapidly removed and cleaned from the printer.*

Initial Results: Ball Valve Part

The combination of Equispheres NExP-1 AlSi10Mg powder and the AconityMIDI+ LPBF 3D printer with top hat configuration led to significant improvements in part density, quality, and production speed. Parts were printed 8 to 9 times faster than the standard material and Gaussian benchmark, while also achieving an 80% reduction in cost.



	Job time	Reduction
Standard	34.5 h	-
NExP 120	10.3 h	~70%
NExP 240	7.5 h	~80%

Parameters:	Standard	**NExP 120**	**NExP 240**
▪ Layer thickness [µm]	60	**120**	**240**
▪ Scan speed [mm/s]	1350	**3500**	**2500**
▪ Build-Up Rate* [cc/hr]	36.5	**302**	**432**

Chart 1. *The combination of Equispheres NExP-1 AlSi10Mg powder and the AconityMIDI+ LPBF 3D printer with top hat enabled significantly improved part density, quality, and production speed. Parts were printed at 8-9 times faster than the standard material / Gaussian benchmark with a cost reduction of 80%.*

However, since the builds were prepared using legacy build preparation software, which only allows the assigning of a single print parameter to the entire part, the result was a rough surface finish. These outdated legacy solutions only allow for one parameter per model, aside from basic upskin and downskin adjustments, offering no ability to differentiate between interior features and surface details of the part.

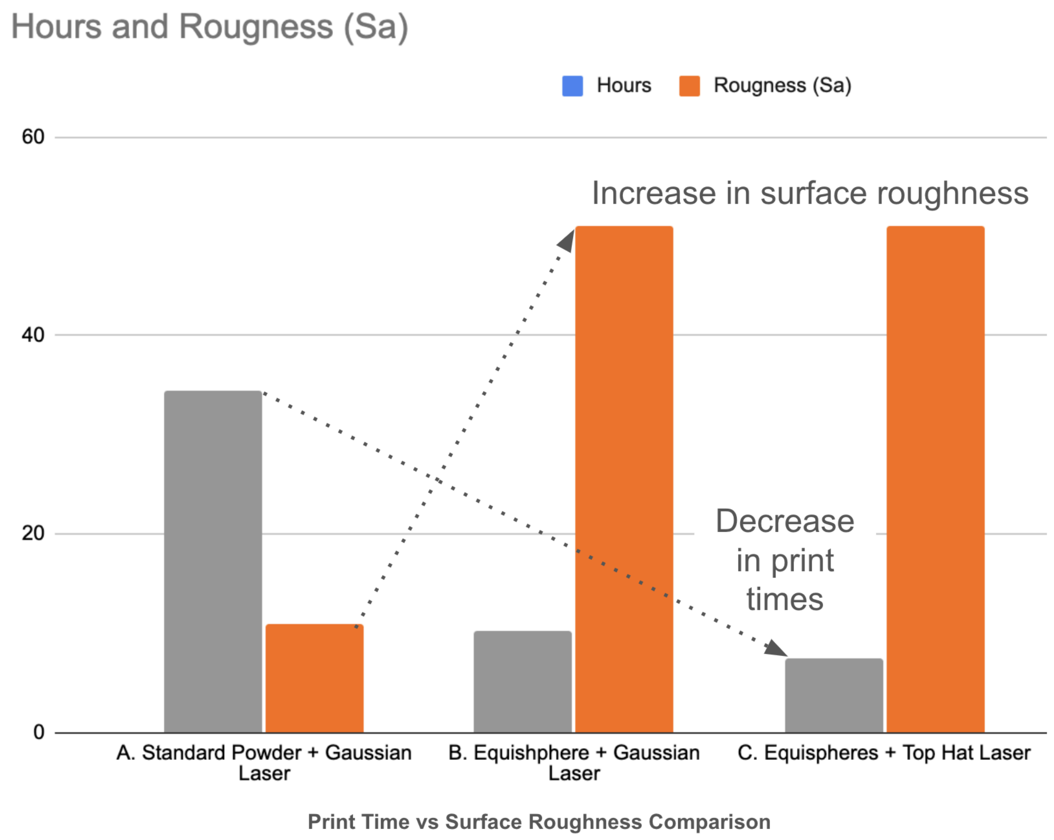


Chart 2: *Comparison of print times vs surface roughness using legacy build prep software.*

"While the test results and production speeds were impressive, the process had no easy provision for the generation of surface-only parameters on the part which would mean higher time and costs for post-processing," said Evan Butler-Jones, VP of Product, Equispheres.

Enter Dyndrite LPBF Pro and 3D Volumetric Segmentation

In search of a solution to the surface quality issue, the research team added Dyndrite LPBF Pro and leveraged its 3D Volumetric Segmentation tools to deliver a visible and testable improvement in surface quality.

Dyndrite LPBF Pro is an advanced software solution designed to optimize additive manufacturing processes through control and automation. Specifically built for laser powder bed fusion, it provides advanced tools for interrogating geometry and assigning parameters tuned to that unique, and often challenging aspect of a design such as low-overhangs. Engineers and materials scientists use Dyndrite to conduct complex materials and process development studies and create scriptable CAD-to-Print automations that streamline the qualification and calibration process. Its automated reporting and build recipes enable a seamless transition from development to full-scale production. Dyndrite's advanced toolpathing capabilities means users can print thin walls, support-free cantilevers, and domes. Users can define parameters that accelerate build rates, and improve surface finishes — all while codifying knowledge, and minimizing human error.

Dyndrite Results: Ball Valve Part

The addition of Dyndrite LPBF Pro resulted in a 62.4% decrease in surface roughness (Sz) and an 80.4% decrease in surface roughness (Sa) with a 21.1% print time increase of about 2 hours when printing at high (240 µm layer heights). Using Dyndrite the team was able to produce prints with significantly smoother surface finish, while maintaining print time productivity gains. A lower surface roughness directly equates to less time post processing - thereby lowering costs, and enabling faster time to part use.

Further, while surface finish has been traditionally correlated to layer thickness – the smaller the layer, the better the finish – this new combination of Equisphere, Aconity 3D, and Dyndrite can deliver comparable surface finish even at much larger layer sizes.

Now you can have your cake and eat it too.

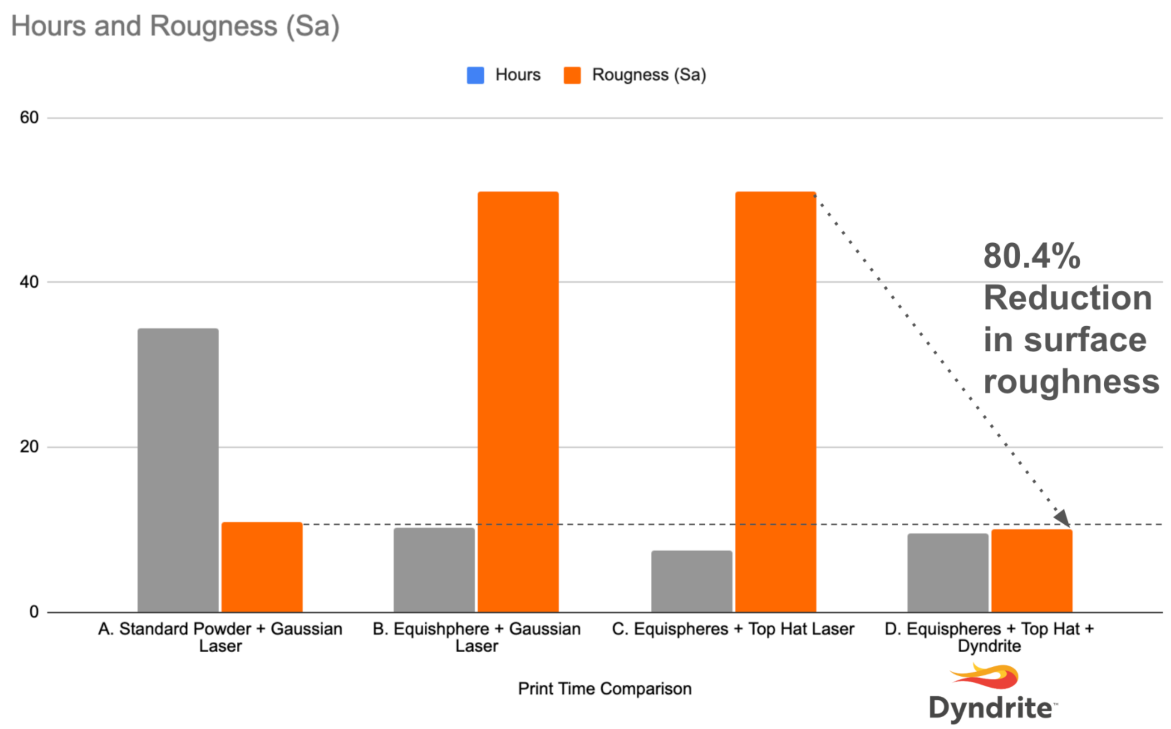


Chart 3: *The addition of Dyndrite in Scenario D resulted in much improved surface finish without a significant increase in print time.*

Data Table: Ball Valve Part

Equipment	Layer Thickness	Build Time	Surface Finish
A: Standard parameters on a conventional AconityMIDI with traditional aluminum powder	70 μm	34.5 hours	Sa = 11 μm / Sz = 163 μm
B. Equispheres' powder and optimized parameters on a conventional AconityMIDI	120 μm	10.3 hours	Sa = 51 μm / Sz = 484
C. Equispheres powder and the AconityMIDI+ outfitted with laser beam shaping and a 3-kW laser	240 μm	7.5 hours	Sa = 51 μm / Sz = 484
D. Equispheres powder, AconityMIDI+ and Dyndrite LBPF Pro software	240 μm	9.5 hours	Sa = 10μm / Sz = 182 μm

Table 1: *The single laser build rate in Scenario C reached 430 cm^3/hr and resulted in 80% lower per part costs than Scenario A because of the reduced print time. The final test parts were produced at a layer thickness of 240 μm. Using beam shaping and NExP-1 material, the build time is only 7.5 hours. The addition of Dyndrite in Scenario D resulted in much improved surface finishes (Sa = 10μm / Sz = 182 μm) and slowed down printing times only in insignificant amounts.*

Dyndrite Results: AconityScan Housing Part

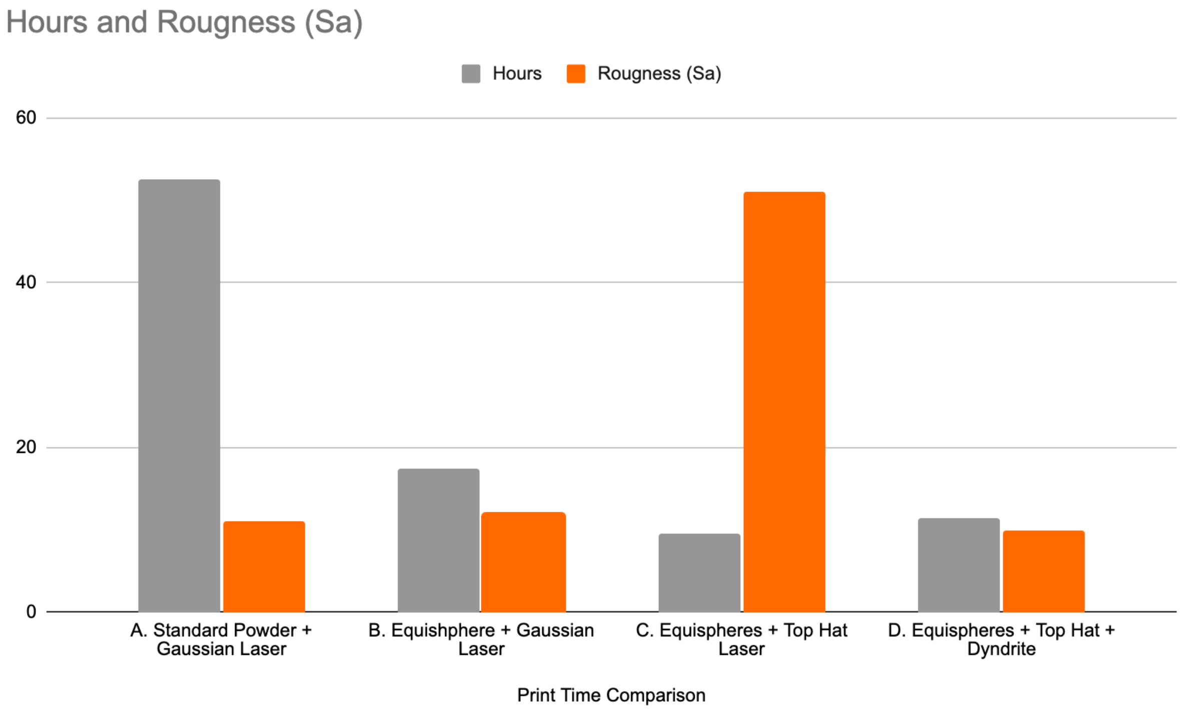


Chart 4: AconitySCAN Housing. Comparing print time and surface roughness (Sa).

Data Table: AconitySCAN Housing

Equipment	Layer Thickness	Build Time	Surface Finish (Sa)	Surface Finish (Sz)
A: Standard parameters on a conventional AconityMIDI with traditional aluminum powder	50 µm	52.8 hours	11 µm	163 µm

B. Equispheres’ powder and optimized parameters on a conventional AconityMIDI	120 µm	17.5 hours	12 µm	189 µm
C. Equispheres powder and the AconityMIDI+ outfitted with laser beam shaping and a 3-kW laser	240 µm	9.5 hours	51 µm	484 µm
D. Equispheres powder, AconityMIDI+ and Dyndrite LBPF Pro software	240 µm	11,5 hours	10µm	182 µm

Table 2: AconityScan housing part parameters

The Future

Testing and research are ongoing, with the team confident that they have only begun to uncover the full potential. They believe further improvements can be achieved by incorporating an nLight ring beam shape and fully utilizing the Dyndrite software to optimize material and part parameter sets.

Aconity3D has previously demonstrated that the nLight AFX ring shape could boost the build rate for a titanium alloy by 7.8x—rising from 5.4 cm^3/hr with a standard single-mode fiber laser to 42.1 cm^3/hr with AFX. This remarkable increase resulted from a 4x expansion in melted volume and nearly doubling the scan rate, all while maintaining excellent material quality (>99.8% density).

Summary

"More and more, we’re seeing the significant impact of fit-for-purpose tools in achieving long-sought objectives in additive manufacturing," said Harshil Goel, CEO of Dyndrite. "We’re proud that our Dyndrite LPBF Pro tool has contributed meaningfully to helping the Equispheres and Aconity3D teams meet their goals. This is yet another clear example of why it's crucial for engineers and operators to move away from outdated, restrictive software tools that limit progress, and instead embrace tools that give them superpowers and engineering excellence. We are showing in real time how the software is now finally meeting the sophistication of both the materials and hardware. I can’t wait to see others print previously impossible things with no supports."

This project achieved a breakthrough in metal additive manufacturing by delivering build rates approximately eight times faster than typical industry standards, without sacrafising surface quality. Given that much of the cost in metal 3D printing is driven by machine time and post-processing, this significant increase in speed, coupled with improved surface finish, drastically lowers overall production costs. The combination of engineered powders, laser beam shaping, and advanced software reshapes the economic viability of metal AM, making it an attractive solution for cost- and quality-sensitive industries like healthcare, automotive, and personal goods. This innovation positions AM as a competitive, scalable manufacturing option in these critical sectors.

"I think what this has demonstrated for me is that we have not hit the limits for LPBF," said Butler-Jones. "With fit for process materials, fit for purpose laser systems, and the right software you can hit throughput and economic targets that open up a huge range of new applications for AM. This has just been one step (though a big one) in a series of ongoing advances, and we are already working to push those boundaries even further."

About Dyndrite

Dyndrite is driving a transformation in additive manufacturing much like how the transition from the manual lathe to the CNC machine revolutionized traditional manufacturing. Just as CNC machines introduced fit for purpose tool heads, automation, and unparalleled efficiency, Dyndrite's software platform brings toolpathing control, computational power, and automation to additive manufacturing, unlocking new levels of performance, productivity, and economics.

Dyndrite enables engineers and operators to achieve greater quality, speed, and scalability, pushing the boundaries of what's possible in additive manufacturing—similar to how CNC machines redefined the potential of machining and production.

To learn more about Dyndrite LPBF Pro go to dyndrite.com/lpbf-product.

About Equispheres

Equispheres develops breakthrough technologies for the production and use of advanced materials in additive manufacturing. Leveraging our unique metal powders and process expertise, we are dedicated to driving forward the industrialization of additive manufacturing for the automotive, aerospace, and defense industries. By lowering the cost and improving the performance of industrial 3D printing, we empower innovation.

To learn more about Equispheres go to equispheres.com/

About Aconity3D

Aconity3D's main business activity is the development of equipment for powder bed laser melting and direct energy deposition of metals. Towards this end, the company seeks to combine maximum functionality in terms of modular open-ended machine concepts at an attractive price structure due to customer specific dispatch. With currently six basic, fully-configurable machine types, a wide range of applications is addressed. Hands-on trainings, workshops, feasibility studies as well as printing metal parts on customers' behalf complete Aconity3D's hardware-portfolio in a holistic implementation concept. Thus, access to powder bed laser melting is expanded and comes within reach even for small and medium sized enterprises.

To learn more about Aconity3D go to aconity3d.com/