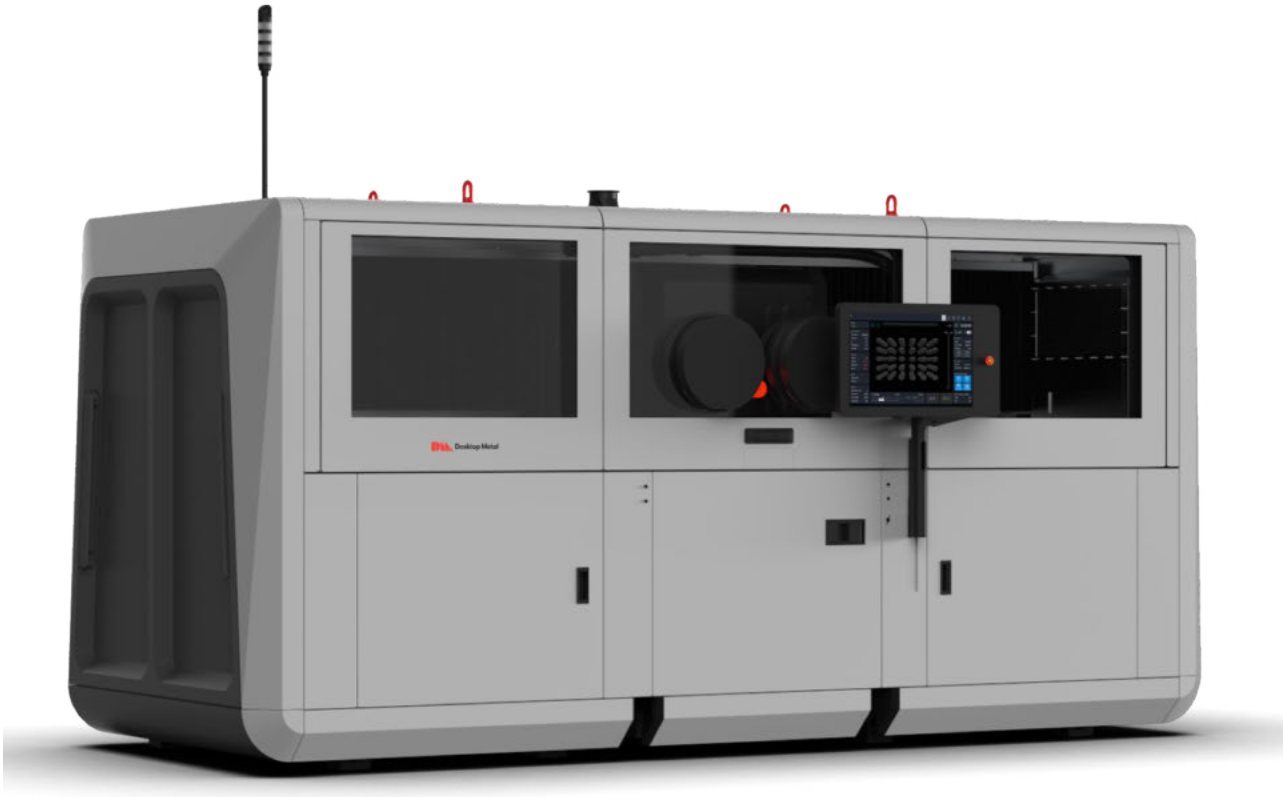
Production System™

Production System: High-speed mass production of metal parts

- Excellent part quality
- Competitive cost per part
- Strong repeatability
- Wide material compatibility



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Production System™

—

High-speed, mass production of metal parts, designed for the factory floor.

- **Mass production volumes** — up to tens of thousands of parts per year
- **Powered by Single Pass Jetting™** technology up to 100x faster than laser powder bed fusion(1)
- **Parts costs competitive with conventional manufacturing** and as low as $0.02 to $100.00(2)
- **Leading repeatability** achieved using patented anti-ballistics technology and real-time optical print bed inspection
- **Wide material compatibility** enabled by an inert processing environment, open material platform, and array of proprietary binders

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1. Based on published speeds of single laser, mid-range laser powder bed fusion systems available as of August 18, 2020.
2. Based on management estimates

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High-speed, mass production of metal parts.

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Designed for the factory floor

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Up to 100x faster than LPBF[1,2]

Up to 95% lower cost than LPBF[1,2]

Print millions of parts per year[1]

Using low-cost MIM powders for both non-reactive and reactive metals, the Production System delivers part costs as low as $0.02 to $100.002.[2]

1. Based on Desktop Metal's internal estimates as of August 12, 2020.
2. Based on published speeds of single laser, mid-range laser powder bed fusion systems available as of August 18, 2020.

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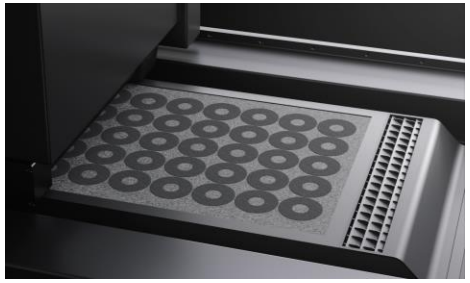
Key features



Single Pass Jetting

Speeds up to 12,000 cc/hr

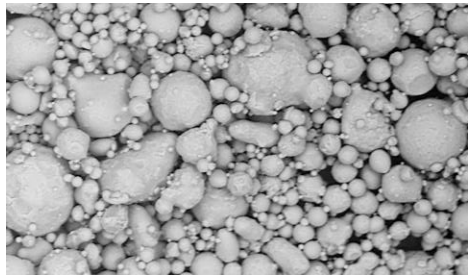
Constant wave spreading

Consistent bed density

High resolution printing

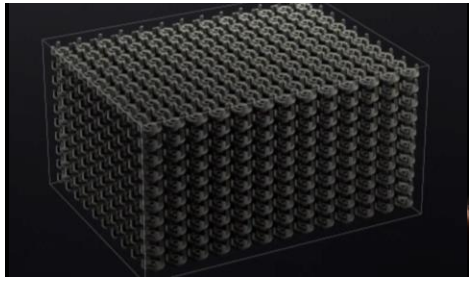
Native 1200x1200 dpi

MEMS piezo-based printhead technology



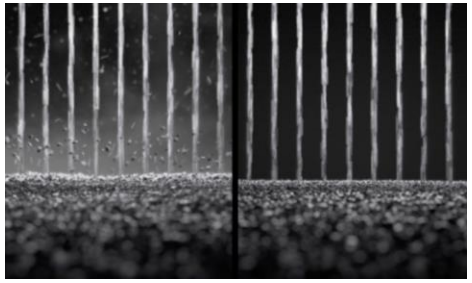
Low cost MIM powders

Up to 99% powder recovery



High density nesting

Fabricate MFG



Anti-ballistics technology

Reliable prints, part quality

Inert processing

And open materials platform

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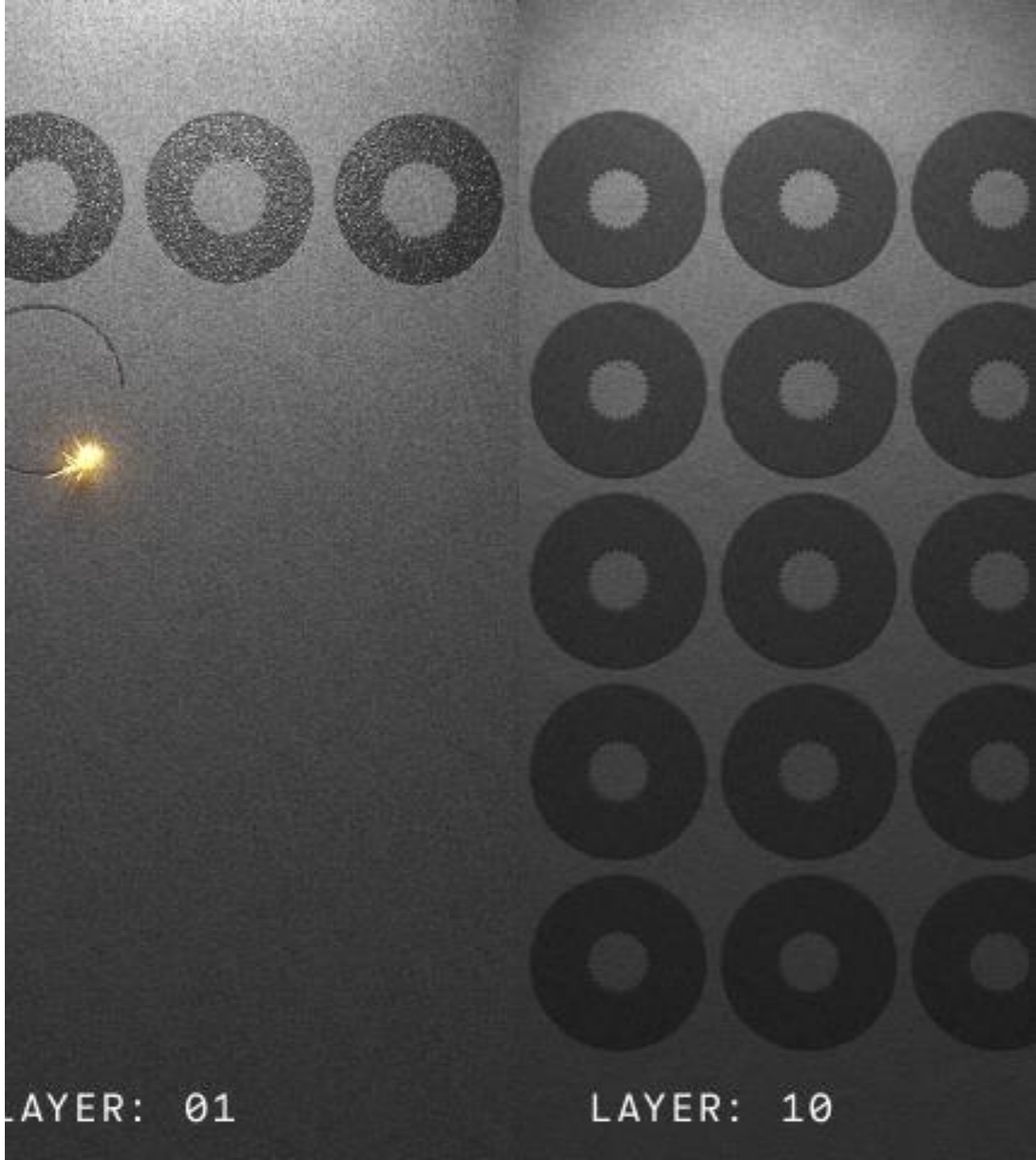
[P-50] Bi-directional Single Pass Jetting™

Print up to 10,000 parts per day[1] with bi-directional SPJ™ technology on the Production System™ P-50, which utilizes each pass of the print carriage to build parts and achieves print speeds of up to 12,000 cc/hr — 100x laser powder bed fusion systems[2] — maximizing productivity and driving down part costs.

- Print a layer with each pass over the build box — no wasted motion or multiple, separate carriages
- Speeds up to 100x laser powder bed fusion systems[2]
- Print millions of parts per year, optimizing part costs[1]



1. Based on Desktop Metal's internal estimates as of August 12, 2020.
2. Based on published speeds of single laser, mid-range laser powder bed fusion systems available as of August 18, 2020.

Constant wave spreading

Proprietary constant wave spreading technology maintains a consistent powder wave in front of the compaction roller during printing, enhancing density uniformity across the powder bed. The result is greater consistency across parts within each build and from build-to-build.

- Pre-compaction during powder dispensing enables high powder bed density
- Achieves highly consistent powder bed density with uniform layer thickness across the entire build box

Industry standard spreading solution with non-uniform powder volume

Production System™ constant wave spreading with consistent powder volume

High resolution printing

With a native resolution of 1200 x 1200 dpi and layer heights as small as 30 µm, the Production System™ is a precision binder jetting solution that can 3D print parts with excellent surface finish and incredibly fine features.

- Native printhead resolution 1200 x 1200 dpi
- Layers heights between 30 µm - 200 µm[1] (green state)
- Typical surface finish below 10 µm Ra

Default profiles available for 50 µm - 100 µm; 30 µm - 200 µm material and powder dependent.

MEMS piezo-based printhead technology

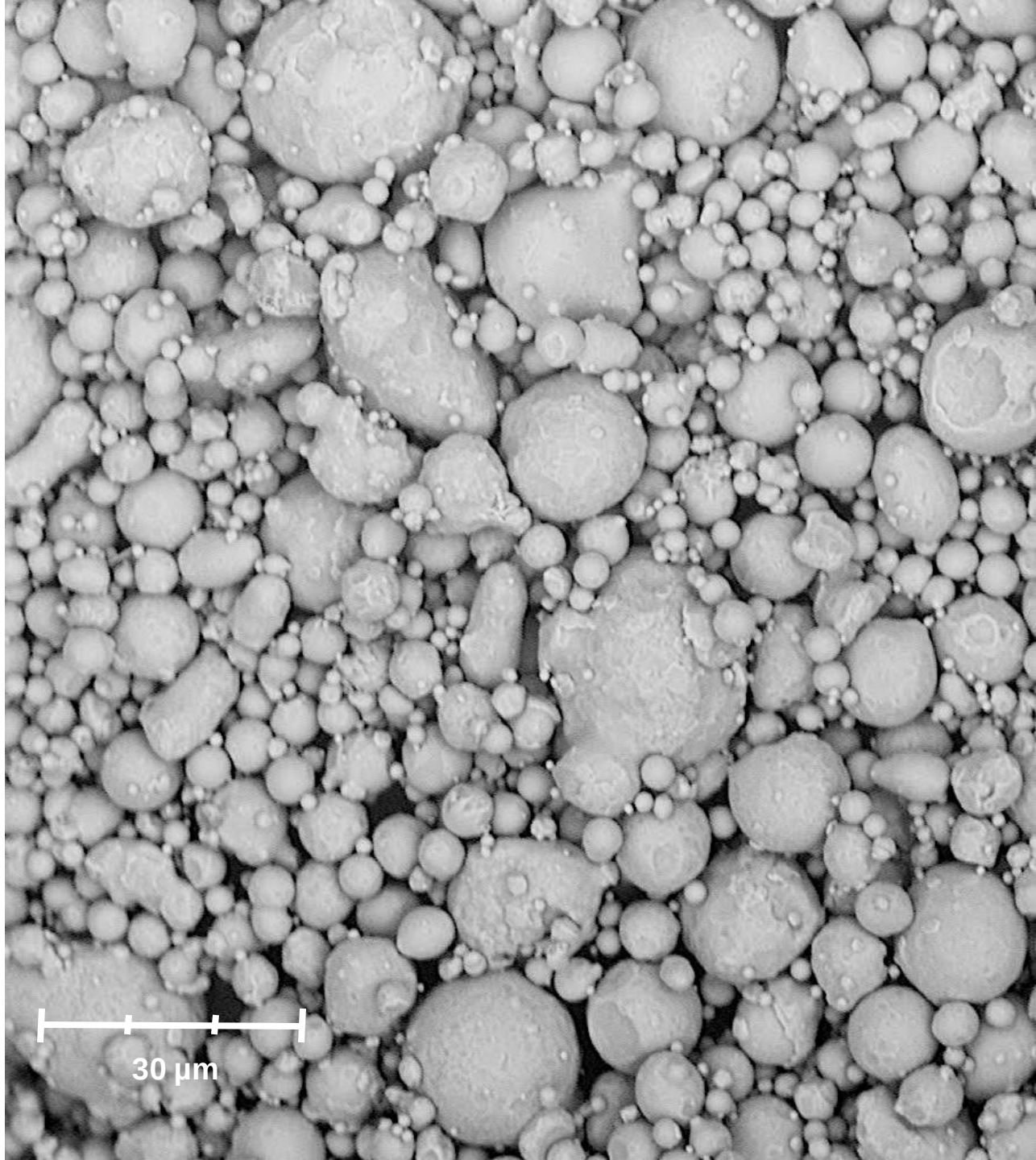
Scalable, MEMs piezo-based printheads enable single pass printing, eliminating the need for scanning printheads commonly found in alternative binder jet systems. In addition, these printheads offer wide binder flexibility, enabling compatibility with a broad array of metals.

- Extremely long-life printheads with low wear
- Recirculation above the nozzles keeps binder fresh and delivers outstanding reliability
- Supports high viscosity binders for strong green parts
- Small native drop size (2.4 pL) enables high precision

Low cost MIM powders

SPJ™ technology uses the same low-cost powders used in the MIM industry, allowing customers to access an established powder supply chain with the scale required to support volume production and a variety of readily usable alloys. As much as 99% or more of the loose powder recovered during the process can be recycled, driving further cost efficiencies while reducing waste.

- Use widely available low-cost MIM powder
- Recycle powder reclaimed throughout the process for future prints



Combine SPJ™ with high-density nesting

The tooling free, SPJ™ process used by the Production System™ means parts are supported by loose powder and do not require welding to a build plate (as in laser powder bed fusion processes). This enables customers to fill the build volume with densely nested parts to efficiently deliver high-throughput builds.

- No welding parts to a build plate, eliminating the need for print supports (and their removal)
- Maximize printer utilization and optimize part costs
- Nest parts automatically with Desktop Metal's Fabricate MFG build prep software (or advanced functionality in third party tools — e.g. Siemens NX, Materialise Magics)

Anti-ballistics technology

Powder bed material ejecta is a leading cause of defects in traditional binder jetting. Proprietary Production System™ anti-ballistics technology drastically reduces variability in the 3D printing process while increasing the longevity of the printheads.

- Engineered to reduce powder bed disturbance and print process variability
- Increases printhead longevity
- Facilitates reliable prints, and excellent part quality

Open material platform

The Production System™ features an open material platform which allows customers to source the same metal powders used in the MIM industry or custom alloys from their supplier of choice, keeping costs low and ensuring compatibility with bulk sintering processes.

- Use low-cost MIM powders available in a wide variety of alloys and in volume
- Adjust key process parameters to optimize part quality

PRAXAIR SANDVIK Höganäs ATMIX DAIDO STEEL VALIMET USMP ArcelorMittal AT&M 安泰科技 AP&C H.C.Starck

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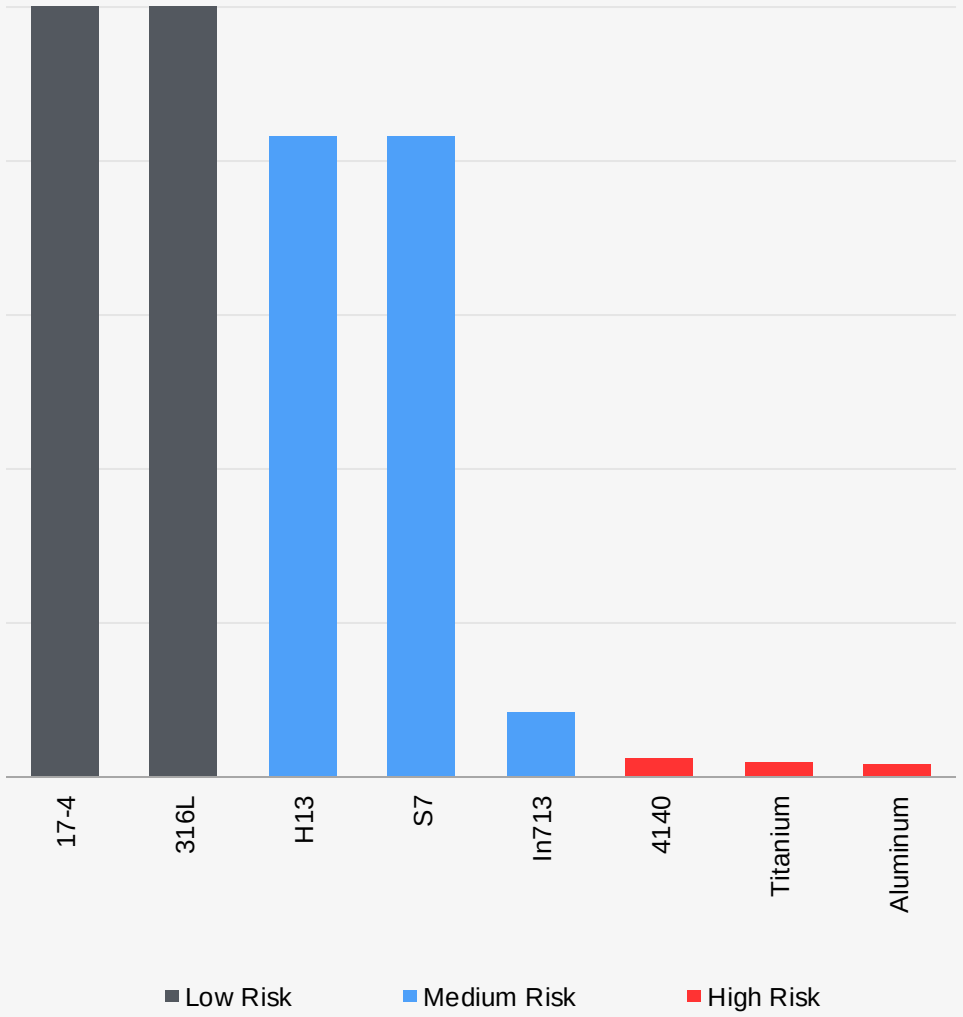
Inert processing for safety and wide material flexibility

A closed powder environment, inerted to < 2% Oxygen, safely supports a range of both non-reactive and reactive metals in a controlled fashion. Isolation from ambient conditions produces powder with consistent characteristics and quality, facilitating part uniformity and repeatability.

- Compatible with reactive metals such as Aluminum, Titanium, and other high-performance alloys
- Most comprehensive method for minimizing safety risks associated with powder-based processes
- Allows the greatest flexibility in powder selection and compatibility while maintaining safety
- Improves final part quality for materials sensitive to oxidation and enables the use of smaller particle sizes more favorable for sintering to high densities

Many applications require explosive metal powders with low MIE (mJ) 1



Risk analysis based on Desktop Metal assessment of metal powder minimum ignition energy (MIE), dust deflagration index (Kst), and maximum explosion pressure (Pmax) as of June 1, 2020.

[P-1] Cost-effective, serial metal parts production

Using SPJ™ technology, the Production System™ P-1 can achieve print speeds of up to 1,250 cc/hr — 10x laser powder bed fusion systems[1] — enabling cost-effective small and complex parts via serialized production. A tooling-free manufacturing process facilitates quick changeovers to new jobs and the ability to print many complex geometries simultaneously.

- Speeds up to 10x laser powder bed fusion systems[1]
- Print multiple builds in a single shift
- Ideal for small and complex parts

Based on published speeds of single laser, mid-range laser powder bed fusion systems available as of August 18, 2020.

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Cost comparison: LPBF vs. SPJ™

	Laser Powder Bed Fusion	SPJ™ (Production System™)
Typical part cost ($)	$100 to $10,000[1]	$0.02 to $100[2]
Quantities	Prototyping & low volume production	Serial & mass production
Key markets	Aerospace and medical	Broad use across automotive, medical, electronics, heavy industry, consumer products, etc.

1. Based on instant quotes provided by www.xometry.com; Desktop Metal's internal estimates as of August 12, 2020.
2. Based on Desktop Metal's internal estimates as of August 12, 2020;

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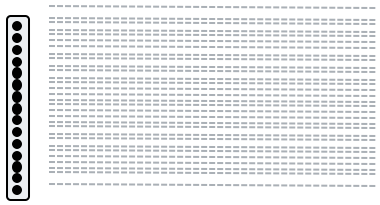
[P-50] Print bar redundancy

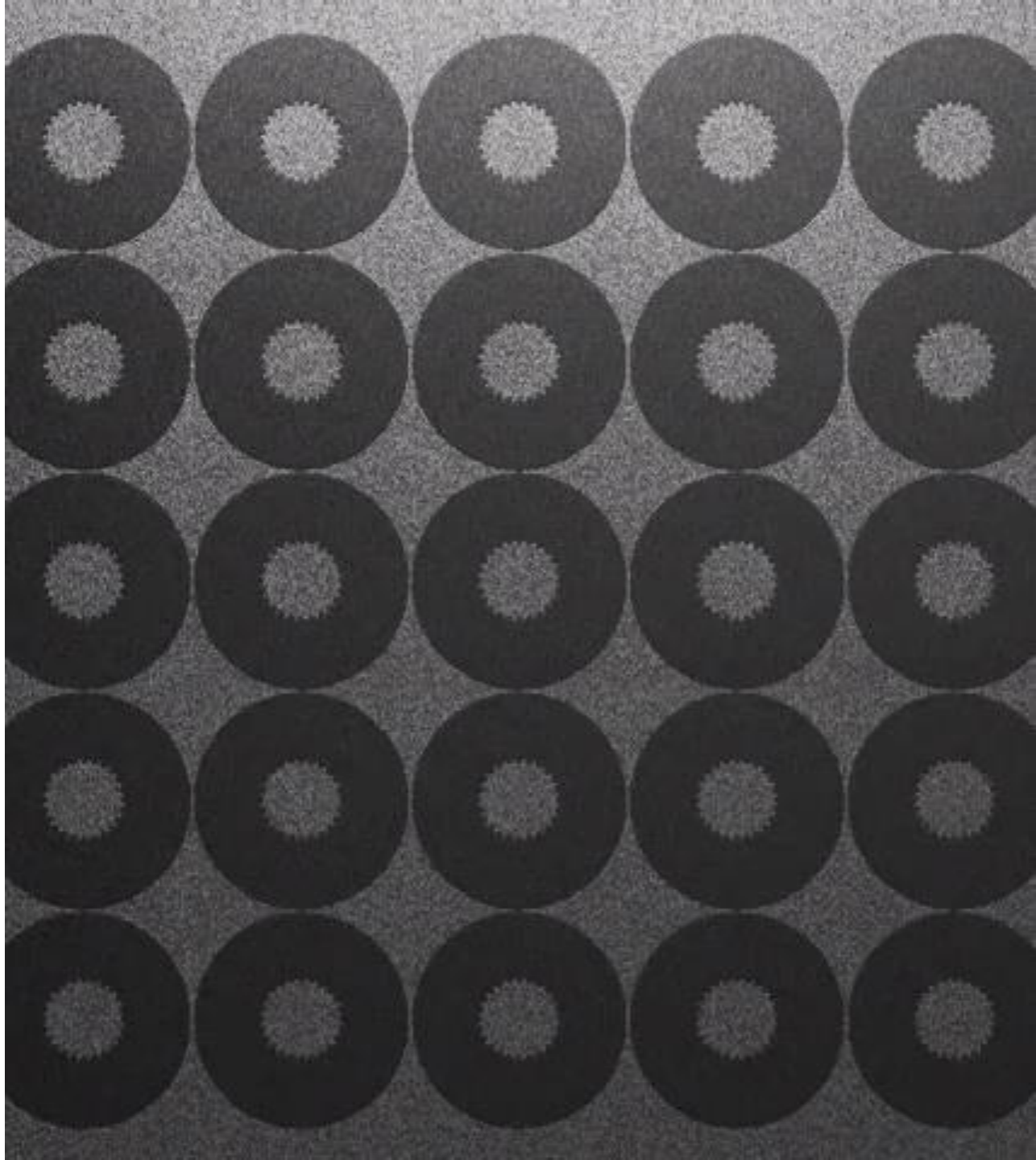
Full print bar redundancy is achieved using an anti-banding mechanism in which the print bar is re-aligned between layers, ensuring reliable binder deposition and suppressing defects that would otherwise affect final part quality. This mechanism eliminates the need for hard, nozzle-based redundancy while improving maintenance accessibility.

- Anti-banding redundancy for high quality printing
- Low-cost, high performance redundancy vs. market alternatives such as additional printheads

Traditional binder jet 3D printing
Multiple printhead redundancy



Production System™
Single printhead banding redundancy



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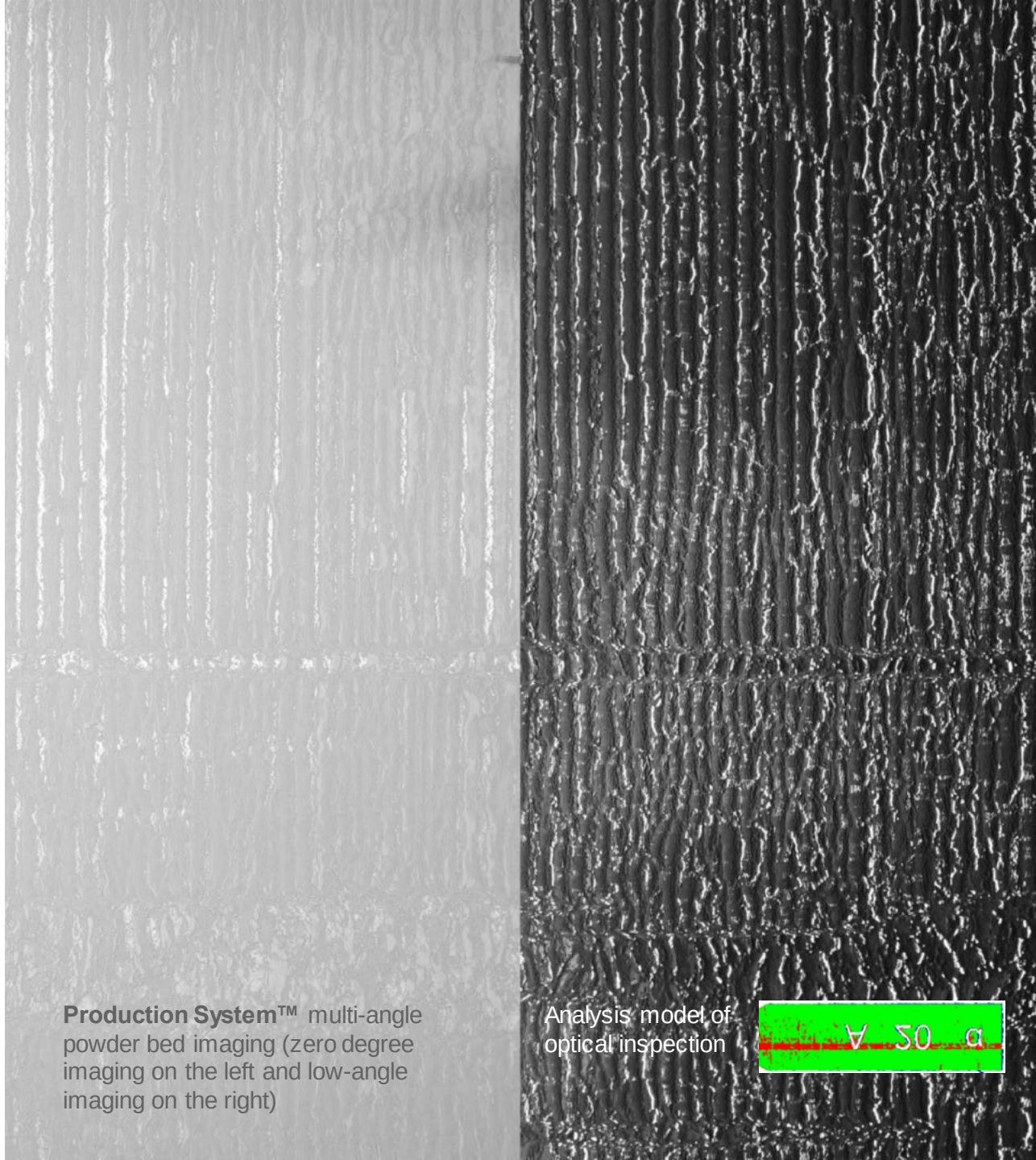
Real-time print bed inspection

An overhead camera monitors each layer to determine print defects and nozzle performance during printing and detect when automated printhead cleaning is required, minimizing and preventing part defects within each build.

- Real-time process monitoring
- Enables robust and reliable printhead performance
- Reduces maintenance requirements



Production System™ multi-angle powder bed imaging (zero degree imaging on the left and low-angle imaging on the right)

Analysis model of optical inspection

A growing portfolio of Desktop Metal engineered binders

Developed by expert materials scientists at Desktop Metal, our proprietary binders are formulated to support a broad array of alloys and to maximize success through every stage of the binder jetting process — ensuring jettability during printing, green part strength during depowdering, and clean burn off prior to sintering.

- Aqueous binders tested for compatibility with stainless steels, tool steels, and precious metals
- Tuned to SPJ™ printheads to provide fast and reliable jetting under a wide range of environmental conditions, extending printhead life by minimizing cleaning cycles
- Print high green strength parts that enable rapid depowdering with high yield
- Low carbon residue in sintered parts

Binder 01 Aqueous binder that leaves little carbon residue and good brown part strength with short curing times. Optimized for stainless steels (such as 17-4PH and 316L).

Binder 02 Non-flammable, aqueous binder that provides good brown part strength and exceptional surface finish. Optimized for precious metals (such as Sterling silver and yellow/rose gold).

Binder 03 Non-flammable, aqueous binder that provides excellent corrosion resistance during entire binder jetting process. Optimized for tool steels (such as S7, H13, and 4140).

Binder R&D Compatibility with reactive metals, specialty alloys, & ceramics.

Binder jetting workflow

01
Print

A full width print bar works in conjunction with powder spreaders to disperse metal powder and print in a single pass across the build area, jetting millions of droplets per second.

02
Crosslink

The build box containing the printed parts is placed into a crosslink oven and thermally processed to remove solvents and solidify the binding agent, strengthening the parts to ensure high yields during depowdering.

03
Depowder

Parts are removed from the build box and cleared of any loose powder that remains in channels and crevices in preparation for sintering.

04
Sinter

Parts are heated to temperatures near melting, and the remaining binder is removed causing the metal particles to fuse together and the parts to densify.

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Models

Production System P-1

- Cost-effective **serial part production**
- **Development bridge** to mass production with the P-50.
- **Wide material compatibility** enabled by an inert processing environment, open material platform, and array of proprietary binders
- **Highly tunable** system supports process and material development and **direct transfer to the P-50**
- **Powered by unidirectional Single Pass Jetting™** technology up to 10x faster than laser powder bed fusion(1)

Production System P-50

- High speed **mass production** up to tens of thousands of parts per year
- **Wide material compatibility** enabled by an inert processing environment, open material platform, and array of proprietary binders
- Leading repeatability achieve using patented anti-ballistics technology and real-time optical print bed inspection
- **Powered by bidirectional Single Pass Jetting™** technology up to 100x faster than laser powder bed fusion(1)

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Based on published speeds of single laser, mid-range laser powder bed fusion systems available as of August 18, 2020.

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Production System™ [P-50]

Technology	Print technology	Single Pass Jetting™
	Print direction	Bi-directional
		8 piezo-electric printheads (16,384 nozzles)
Performance	Max build rate	12,000 cc/hr (732 cu in/hr)
	Layer thickness	30 µm - 200 µm[1]
	Resolution	Native 1200 DPI
Physical	External dimensions	1.9 x 5.0 x 1.9 m (75 x 197 x 75 in)
	Build box size	490 x 380 x 260 mm (19.2 x 15.0 x 10.2 in)
	Chamber environment	CDA or Nitrogen inerting (< 2% Oxygen)
		380 - 480V, 50/60 Hz, 3-phase, 4 wire 60 Amp
Powders		Open platform (third party MIM powders)
	Oxygen concentration	LOC ≥ 3.4% (with Nitrogen inerting)

1. Default profiles available for 50 µm - 100 µm; 30 µm - 200 µm material and powder dependent.

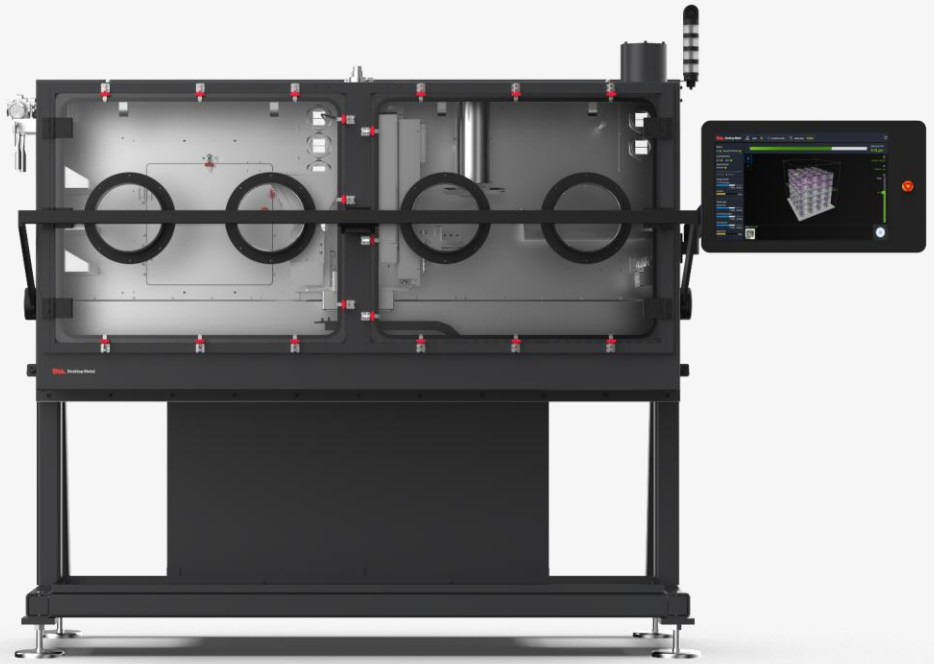
[P-50] Integrated, closed-loop manufacturing system

The Production System™ Printer, Powder Processing Unit, and Powder Station are integrated to form a closed-loop, controlled powder environment required to achieve uniformity, yield, and repeatability in the binder jetting process.

- Powder is isolated from ambient conditions
- Automated powder handling & conveyance between Printer, Powder Processing Unit, and Depowder Station
- Inert process atmosphere (< 2% oxygen)
- Supports reactive metals with LOC ≥ 3.4%

Production System™ [P-1]

Technology	Print technology	Single Pass Jetting™
	Print direction	Uni-directional
		2 piezo-electric printheads (4,096 nozzles)
Performance	Max build rate	1,250 cc/hr (76 cu in/hr)
	Layer thickness	30 µm - 200 µm[1]
	Resolution	Native 1200 DPI
Physical	External dimensions	1.8 x 2.0 x 1.2 m (71 x 78 x 48 in)
	Build box size	200 x 100 x 40 mm (7.9 x 3.9 x 1.6 in)
	Chamber environment	CDA or Nitrogen inerting (< 2% Oxygen)
		380 - 480V, 11 A 3-phase, 50/60 Hz, 4 wire
Powders		Open platform (third party MIM powders)
	Oxygen concentration	LOC ≥ 3.4% (with Nitrogen inerting)



1. Default profiles available for 50 µm - 100 µm; 30 µm - 200 µm material and powder dependent.

[P-1] Compatible with third party auxiliary equipment

Recommended third party auxiliary equipment for the P-1 Printer:

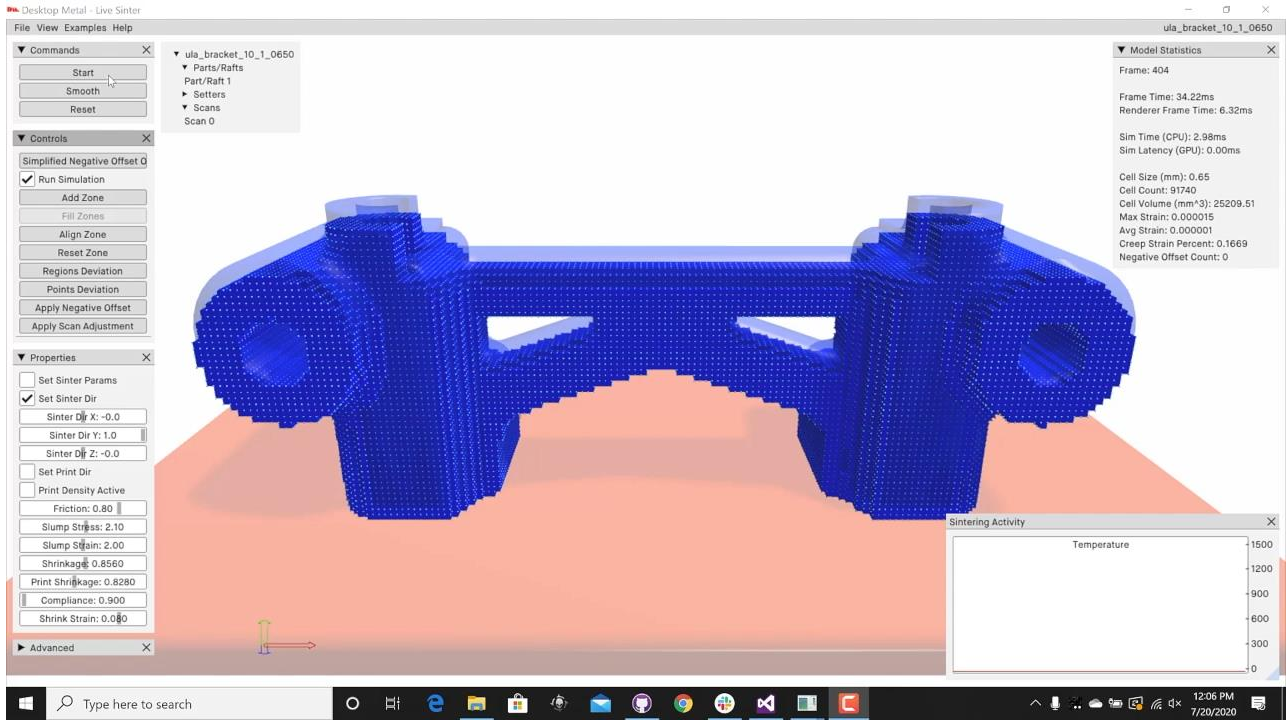
Crosslinking & depowdering	MBraun oven & glovebox
Powder handling	Cleveland benchtop sieve
	Cole Parmer jar mill
	QAQC 5L powder containers
Measurement	McMaster lab scale & lab benches
Housekeeping	Tiger Vac vacuums

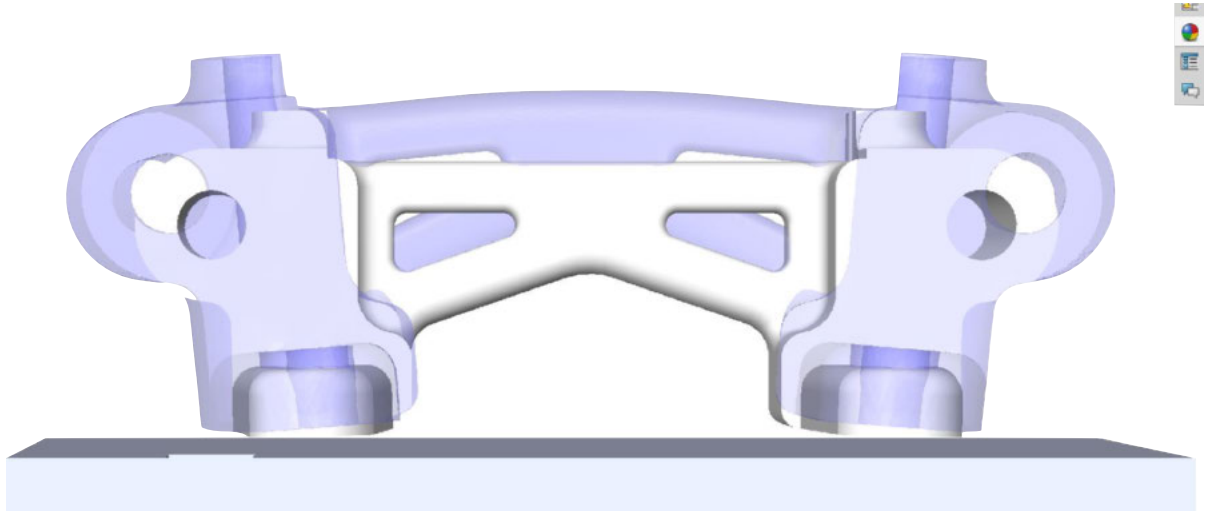
Note: Images for illustrative purposes only. Actual third party equipment may differ.

Live Sinter Software

Sintering is the critical step in manufacturing parts via binder jetting that directly influences final part density and material properties. The process typically results in shrinkage and distortion that requires experimentation with sintering setters to control. Desktop Metal offers software that dynamically simulates sintering and predicts its affect on green parts produced via binder jetting, enabling automated geometry compensation to facilitate greater accuracy and cost reduction

- Dynamic sintering simulation powered by GPU-accelerated, multi-physics engine and artificial intelligence
- Enables optimization for powders & sintering profile
- Automated geometry compensation for distortion to achieve greater accuracy and reduced costs (setters)





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Wide variety of capabilities & applications

Complex, generative design

Internal channels

Consolidated assemblies

Jewelry

Automotive components

Brackets

Serialized tools

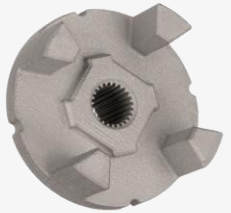
Light weighting

Non-circular holes

Undercuts

Mass customized surgical tools

Consolidated motor components



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