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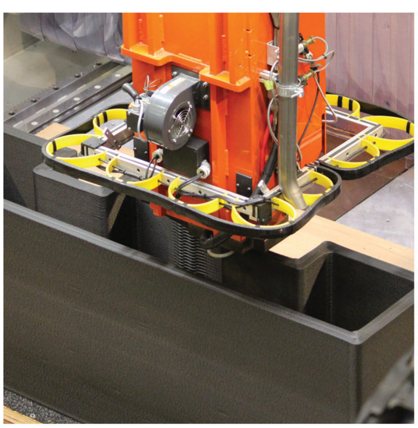
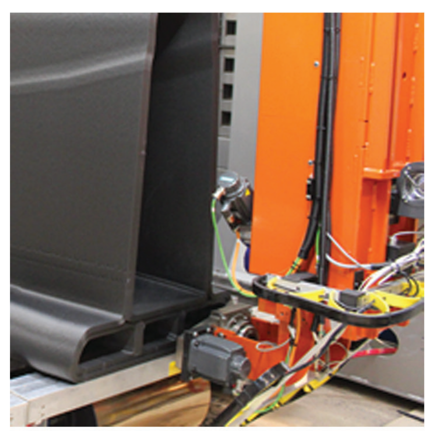
# LSAM

Large Scale Additive Manufacturing





THERMWOOD

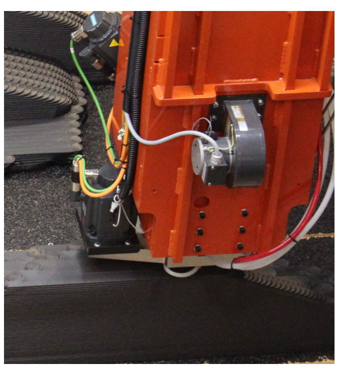
# What is LSAM?

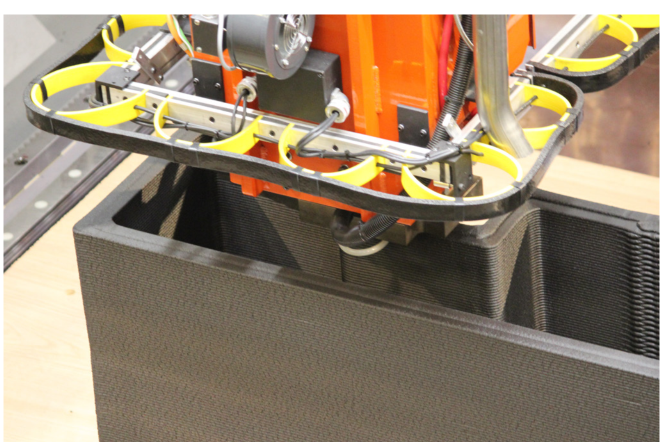
LSAM (pronounced L-Sam) represents the industry leading technology for large scale 3D printing of thermoplastic polymers. LSAM utilizes unique patented technology to produce the highest quality printed structures available.

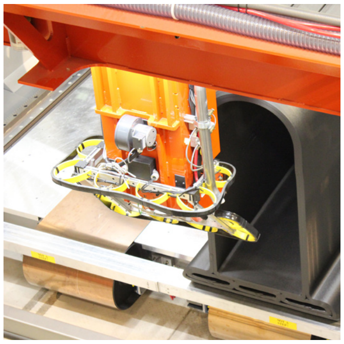
LSAM uses the “Near Net Shape” approach to part production where the part is first printed at high speed slightly larger than needed, then trimmed to the final size and shape. This is the fastest, most efficient method of 3D printing large structures. With LSAM, both printing and trimming can be done on the same machine.

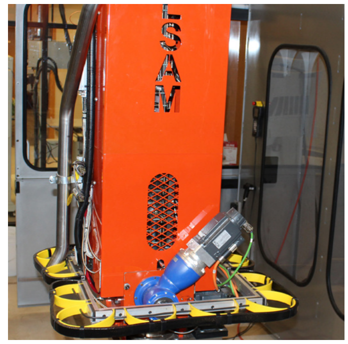
LSAM can process parts from virtually any thermoplastic composite material including high temperature materials that are ideal for molds and tooling that must operate at elevated temperatures. LSAM’s unique printing system produces parts that are solid, fully fused, vacuum tight and virtually void free.

LSAM is intended for serious industrial production. It is not a lab, evaluation or demonstration machine, but is instead a full-fledged industrial additive manufacturing system intended for the production of large scale components.









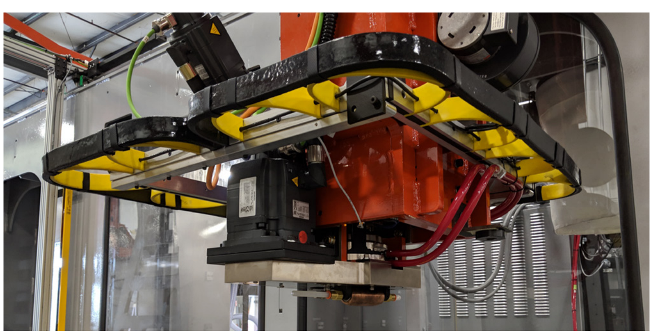

# Advantages of Additive Manufacturing

Traditionally parts have been made by machining an oversized blank, removing material to achieve the final net shape. Often more material is removed than remains. Near-net-shape additive manufacturing prints a part that is nearly the final size and shape then trims it to final dimensions. The amount of material removed is much less, resulting in faster processing, lower cost and more efficient use of material. It is an ideal approach for really large parts where alternate production methods may not be possible.

With the proper choice of material, it may be possible to skip building a master and go directly from a computer design to printing a working mold, saving even more time and money.

For industrial tooling, this direct digital, additive manufacturing approach is substantially faster and dramatically less expensive.

# Advanced MELT CORE LSAM Print Heads

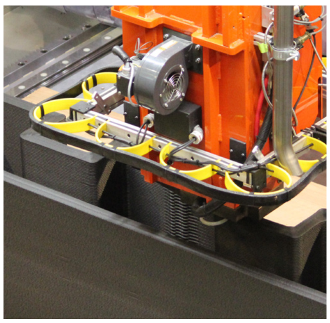


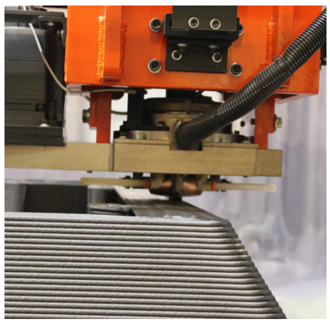
LSAM machines use a new, Thermwood developed, “MELT CORE” print head. Advantages of this design include much tighter control of print bead size, the ability to change bead dimensions while printing, the ability to print at high output rates without surging problems, better fusion between printed layers and a more void free printed structure.

This unique print head design incorporates three servo drives, but unlike the servo drives that operate the machine, they are not programmable machine axes.

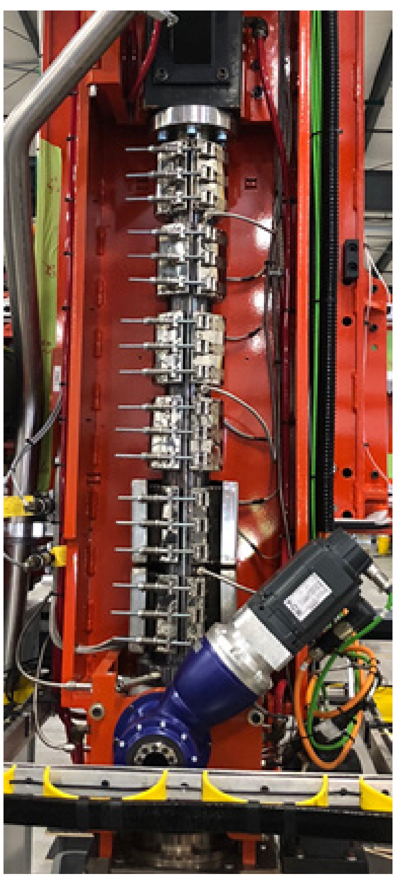
Thermwood’s new design uses a servo controlled plastic extruder with a specially designed plasticating screw to heat and soften the composite thermoplastic material. It then uses a servo controlled fixed displacement polymer pump to deliver the softened material at a highly controlled rate to the print nozzle. This dual servo, two-step approach to generating the print bead eliminates a variety of problems encountered when trying to use an extruder alone to print. It allows much faster print rates without extruder surging, a common problem when operating extruders at high output rates.

Once the bead has been applied, a unique servo controlled compression wheel flattens and fuses each new printed layer to existing layers. Orienting this wheel with the print nozzle is the third servo drive in the MELT CORE series print head. It automatically tracks machine motion, following directly behind the print nozzle, regardless of what direction it moves.





Since it tends to squeeze out air that might otherwise be trapped between layers, this compression wheel results in superior bonding between printed layers and a better, void free structure.



Thermwood's additive print head housing can accommodate interchangeable melt cores. A melt core consists of a feed housing, extruder and polymer melt pump and determines just how fast material can be printed.

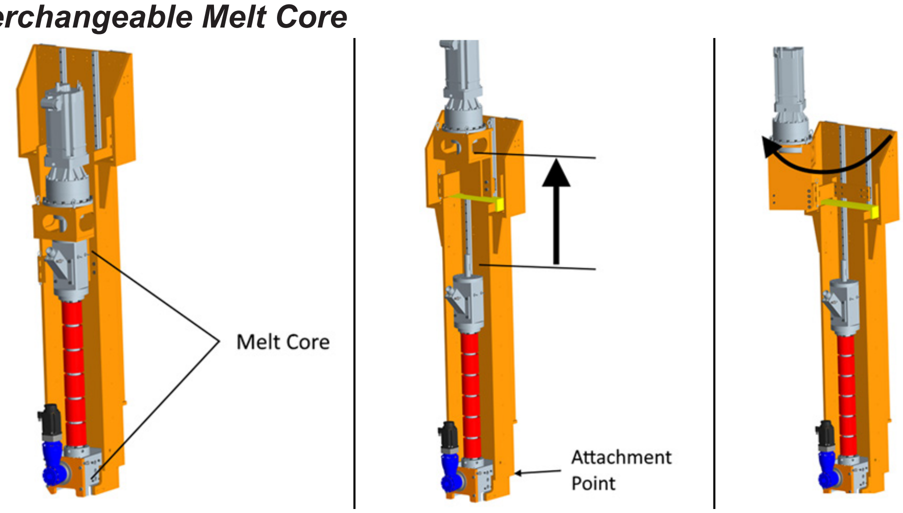
The standard 40mm melt core has a maximum output of between 190 and 210 pounds (86.2kg and 95.3kg) per hour, depending on the polymer being printed, which translates to 40 - 50 feet (12.2m-15.2m)of standard bead (0.83"x0.20") (21mm x 5mm) per minute.

The new 60mm melt core has been tested with different polymers and has achieved print rates from 480 to 570 pounds (217.7kg and 258.5kg) per hour, which translates to well over 100 feet (30.5m) of bead per minute. This higher output capability means you can print layers with 250 feet (76.2m) or more bead length with most polymers, opening important new possibilities for the print process.

With Thermwood's room temperature "Continuous Cooling" print process, the cycle time for each layer is determined solely by how long it takes a particular printed polymer to cool to the proper temperature to accept the next layer.

Only by printing when the previously printed layer is within the proper temperature range can you achieve a completely solid, void free printed structure that maintains vacuum in an autoclave without a secondary coating. This is as fast as you can print a layer.

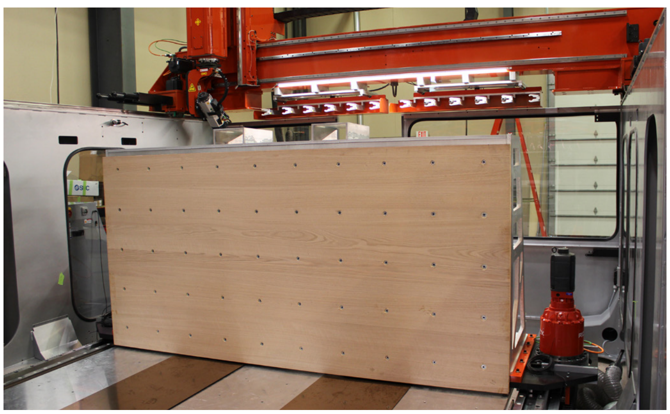
***Interchangeable Melt Core***



The print head output then determines how much material can be printed during the time it takes for the layer to cool. Bigger print heads mean bigger parts not faster layer to layer print time.

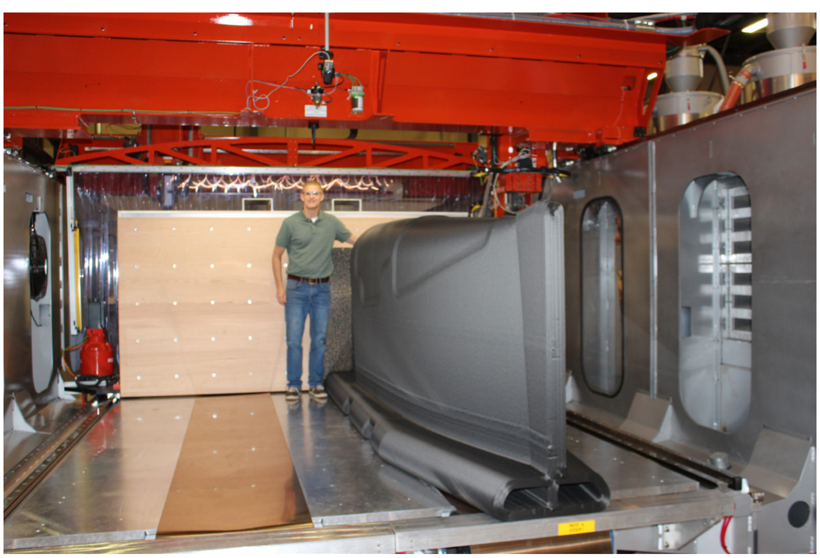
If a user needs both small and large parts on the same machine, the melt cores can be switched in less than a shift.

# Vertical Layer Printing



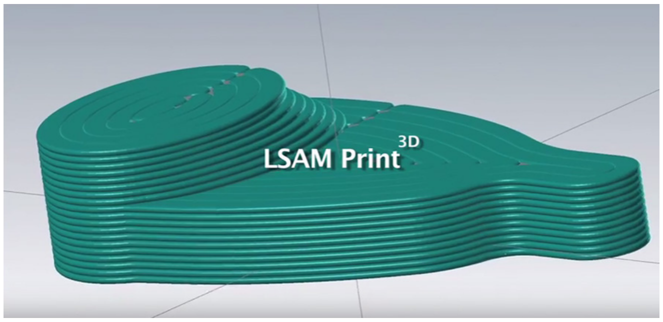
Vertical Layer Printing which allows parts to be printed that are as long as the machine table. In this process, however, the layer stack direction is along the length of the part. This works well for room temperature or low temperature patterns, fixtures and molds, however, for high temperature molds, for use in an autoclave for example, the thermal expansion (CTE) along the stack direction is as much as 20 times greater than along the bead direction. Therefore, it is desirable to print long tools with the bead oriented in the long direction, however, print heads, even Thermwood's 200 pound (90.7kg) per hour head, currently the largest in the industry, have been too slow for this…until now.

The high print rate of the new melt core, even when processing high temperature materials, allows the print bead to be oriented along the length of the tool, even for tools that are as long as the machine table itself.



# The Process

## Software




The process starts with a 3D computer model of the part. This design, in an industry standard solid, surface or mesh file format, is loaded into Mastercam software. Thermwood's LSAM Print$^{3D}$ software utility, which operates within Mastercam, is used to generate the CNC print program needed to print the part using the print gantry. Both a working copy of Mastercam and Thermwood's LSAM Print$^{3D}$ software utility are required to develop a print program.

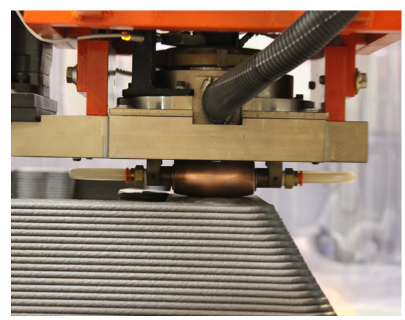
The 3D computer model is then used to generate a trim program which is used to trim the part using the trim gantry.

The printing process consists of heating carbon fiber reinforced thermoplastic material until it is soft and pliable and then laying it down as a continuous bead, layer by layer, until the part shape has been generated. Each new layer fuses with existing layers to produce a solid, strong, void free part.

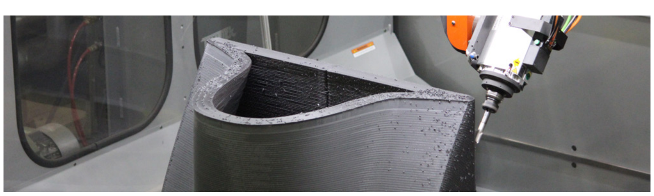
## Printing

The pelletized thermoplastic material is first dried to remove any moisture and then pneumatically conveyed to a vertically mounted print head. The print head heats the material to a softened state and meters the material at a precise controlled rate through a print nozzle. This advanced print head design automatically coordinates with machine motion to maintain precise print bead dimensions, even at very high print rates. It can also change print bead dimensions during the print process as needed.

LSAM uses a bead compression wheel to shape and flatten the extruded bead and fuse it with existing layers. This wheel is servo controlled to automatically follow machine motion.



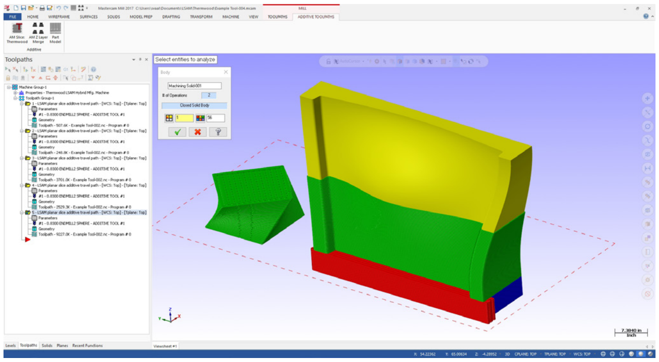
## Trimming



LSAM Trimming is accomplished using a five axis CNC router mounted on a separate 5 axis trim gantry which rides on the same overhead rails as the print gantry.  (The 5 Axis trim head is optional on the LSAM MT and mounts to the same ganty as the print head.) It uses a 12 HP (9kw), 3000 to 24,000 RPM automatic tool change spindle with a ten position automatic tool changer.

The vertical Z axis stroke is a foot higher than the maximum print height, so that the router head can machine from the print table surface to a point completely over the top of a printed part. The trim gantry is also equipped with an automatic tool length measurement system and Thermwood's patented impact resistant head. The machine uses Siemens Intelligent Servo Drives throughout, including the print head drives.

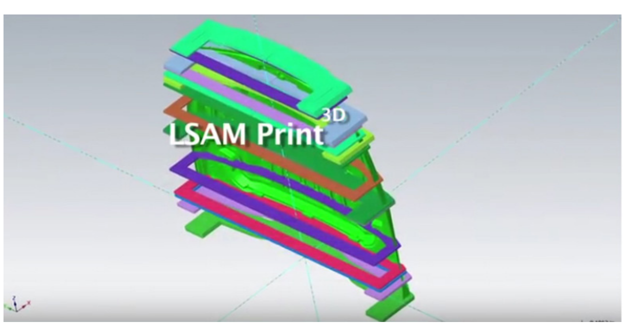
# LSAM Printing Software



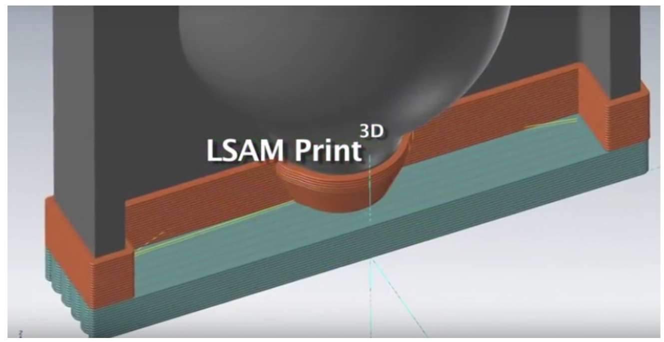
Most 3D printing software is designed for small machines that output a small bead in thin layers to print parts to the final net size and shape. Thermwood's approach is fundamentally different, so existing software doesn't work. LSAM machines use a "near-net-shape" approach where parts are printed layer by layer to a size that is slightly larger than needed and then the printed part is accurately trimmed to the final net size and shape using a CNC router. The software must not only accommodate relatively large bead sizes, whose size can be dynamically changed by programming, but must also print to a size which provides sufficient trim stock for the final trimming process.

To address this, Thermwood offers an additive manufacturing software utility for its LSAM machines called LSAM Print$^{3D}$ which operates within Mastercam, featuring multiple printing options and techniques which are essential for "near-net-shape" additive printing of large components.

To create a print program using LSAM Print$^{3D}$, an initial 3D computer model is generated using a CAD system.

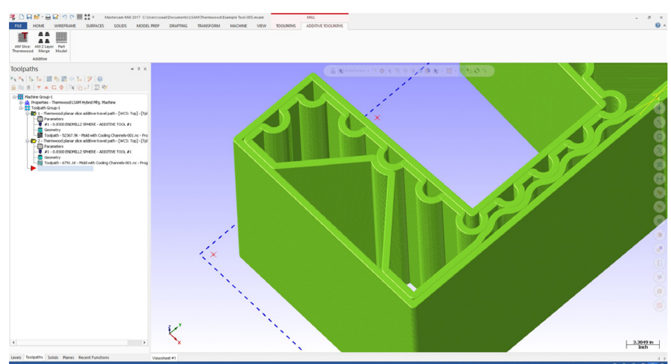



The 3D computer model, in an industry standard solid, surface or mesh file format, is loaded into Mastercam software and Thermwood's LSAM Print$^{3D}$ utility is used to create a print model and generate the CNC machine code needed to actually print the part.




Then a CNC trim program is generated to trim the part to size.

Certain unique print patterns and features, beneficial for making masters, molds, and tooling, have been integrated into the LSAM Print$^{3D}$ software utility. These include the ability to vary bead width during printing, the ability to print asymmetrical wall thickness with some walls thicker than others, and the ability to vary wall thickness from layer to layer.



By incorporating the printing software within Mastercam, a single software can be used to create programs for both printing and subsequent trimming. If desired, this approach easily integrates with existing CAD/CAM systems for everything but the print programming function.

# LSAM Specifications


| | LSAM 55 AP | LSAM 510 AP | LSAM 105 AP | LSAM MT | LSAM 1010 | LSAM1020 | LSAM1040 | LSAM 1520 | LSAM 1540 |
|---|---|---|---|---|---|---|---|---|---|
| Configuration | Moving Table Single Fixed Gantry | Moving Table Single Fixed Gantry | Moving Table Single Fixed Gantry | Moving Table Single Fixed Gantry | High Wall Fixed Table Single Gantry | High Wall Fixed Table Dual Gantry | High Wall Fixed Table Dual Gantry | High Wall Fixed Table Dual Gantry | High Wall Fixed Table Dual Gantry |
| Table (Wide x Deep) | 5 'x 5' Moving | 5'x 10' Moving | 10'x 5' Moving | 10'x 10' Moving | 10'x 10' Fixed | 10'x 20' Fixed | 10'x 40' Fixed | 15'x 20' Fixed | 15'x 40' Fixed |
| Max Print Height | 4' | 4' | 4' | 5' | 5' | 5' | 5' | 5' | 5' |
| Vertical Layer Print | N/A | Optional | N/A | Optional | N/A | Optional | Optional | Optional | Optional |
| Operation | Print Only | Print Only | Print Only | Sequential Print & Trim | Sequential Print & Trim | Simultaneous Print & Trim | Simultaneous Print & Trim | Simultaneous Print & Trim | Simultaneous Print & Trim |
| Available Print Only | Yes | Yes | Yes | Yes | Yes | No | No | No | No |
| Available Print Heads | 40mm | 40mm | 40mm | 40mm | 40mm | 40mm Standard 60mm Optional | 40mm Standard 60mm Optional | 40mm Standard 60mm Optional | 40mm Standard 60mm Optional |
| Max Print Rate (lbs/hr) Polymer Dependent | ≈ 100 | ≈ 100 | ≈ 100 | ≈ 200 | ≈ 200 | ≈ 200 (40mm) ≈ 500 (60mm) | ≈ 200 (40mm) ≈ 500 (60mm) | ≈ 200 (40mm) ≈ 500 (60mm) | ≈ 200 (40mm) ≈ 500 (60mm) |
| Max Part Weight (lbs) | 1,000lb | Standard Print 1,000lb Vertical Print 2,000lb | Standard 1,000lb 2,000lb (w/Opt 2nd Drive) | 5,000lb | Stanard- No Practical Limit | Standard- No Practical Limit Verticle Print- 50,000lb | Standard- No Practical Limit Vertical Print- 50,000lb | Standard- No Practical Limit Vertical Print- 50,000lb | Standard- No Practical Limit Vertical Print- 50,000lb |
| Max Print Temperature | 450 °C | 450 °C | 450 °C | 450 °C | 450°C | 450°C | 450 °C | 450°C | 450 °C |
| Single Hopper Dryer | Standard | Standard | Standard | Standard | Standard | Optional | Optional | Optional | Optional |
| Dual Hopper Dryer | Optional | Optional | Optional | Optional | Optional | Standard | Standard | Standard | Standard |
| Thermal Sensor Automation | Optional | Optional | Optional | Standard | Standard | Standard | Standard | Standard | Standard |

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