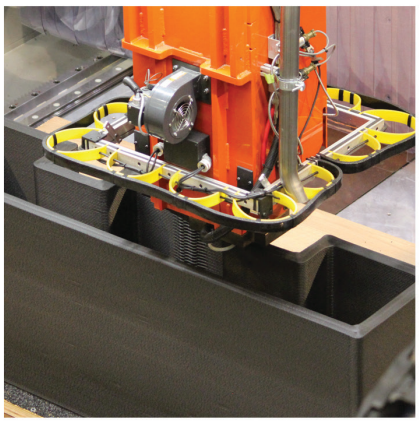
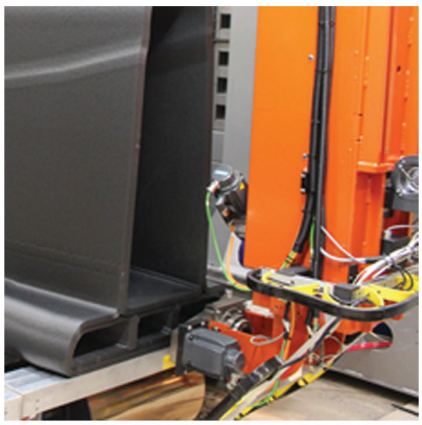
LSAM

Large Scale Additive Manufacturing





THERMWOOD

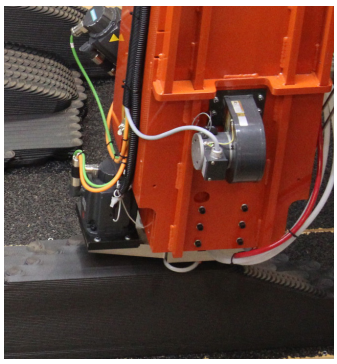
What is LSAM?

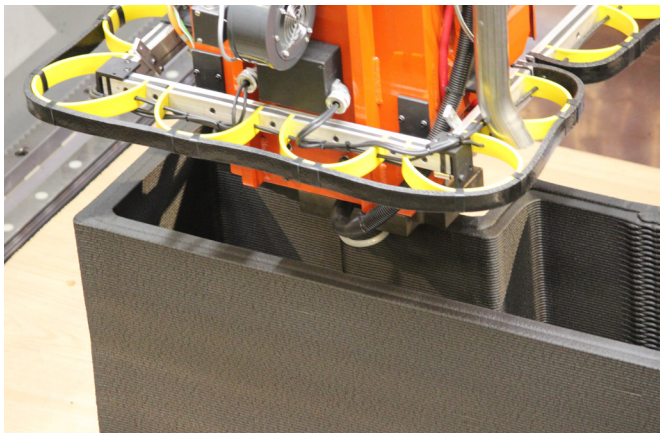
LSAM (pronounced L-Sam) represents the industry leading technology for large scale 3D printing of thermoplastic polymers. LSAM utilizes unique patented technology to produce the highest quality printed structures available.

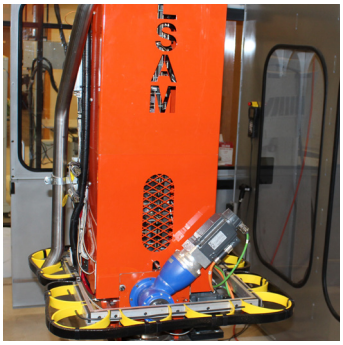
LSAM uses the "Near Net Shape" approach to part production where the part is first printed at high speed slightly larger than needed, then trimmed to the final size and shape. This is the fastest, most efficient method of 3D printing large structures. With LSAM, both printing and trimming can be done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







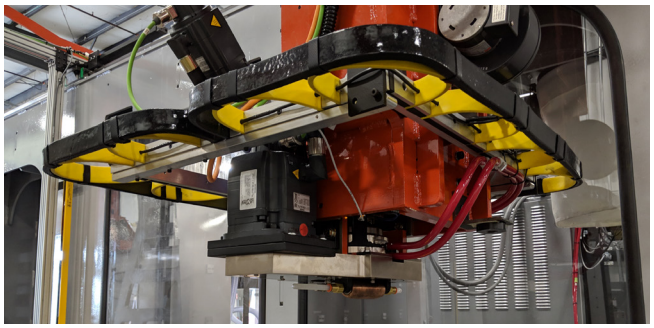
Advantages of Additive Manufacturing

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.

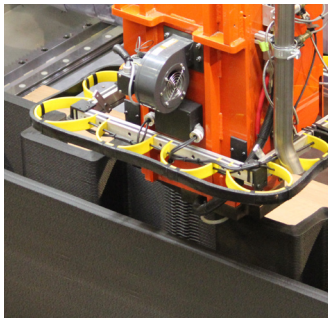
This unique print head design incorporates three servo drives, but unlike the servo drives that operate the machine, they are not programmable machine axes.

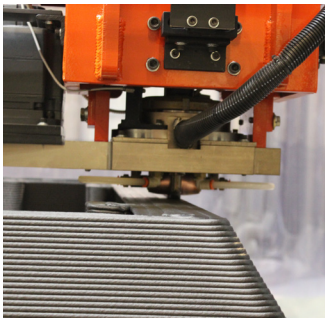
Thermwood's new design uses a servo controlled plastic extruder with a specially designed plasticating screw to heat and soften the composite thermoplastic material. It then uses a servo controlled fixed displacement polymer pump to deliver the softened material at a highly controlled rate to the print 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

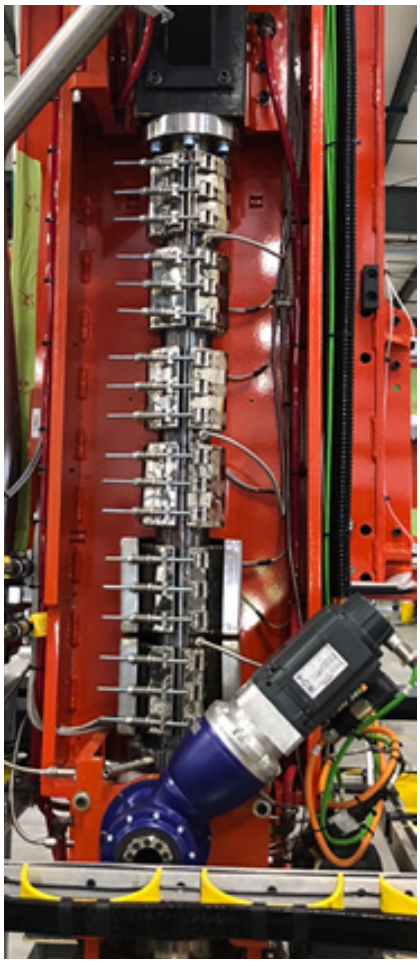
each new printed layer to existing layers. Orienting this wheel with the print nozzle is the third servo drive in the MELT CORE series print head. It automatically tracks machine motion, following directly behind the print nozzle, regardless of what direction it moves.

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.

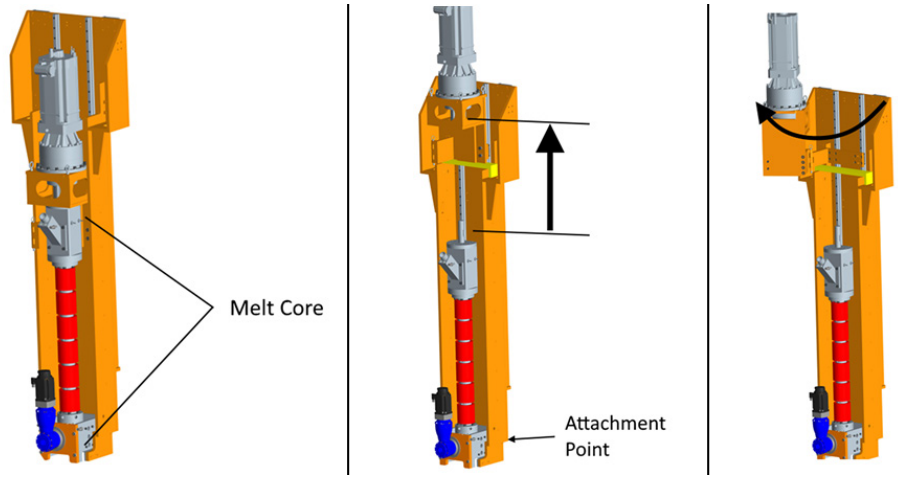
With Thermwood's room temperature "Continuous Cooling" print process, the cycle time for each layer is determined solely by how long it takes a particular printed polymer to cool to the proper temperature to accept the next layer.

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.

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.

Interchangeable Melt Core



Printing Head Options

Thermwood has added a third print orientation to its LSAM Large Scale Additive Manufacturing systems.

LSAM systems currently can print both horizontal and vertical layers if equipped with the Vertical Layer Print (VLP) option, available on most Thermwood LSAM machines. This new addition adds Angle Layer Printing (ALP) to the VLP option. Angle Layer Printing is the ability to print at a 45 degree angle.

Printing Head Options

LSAM systems can print in three positions:

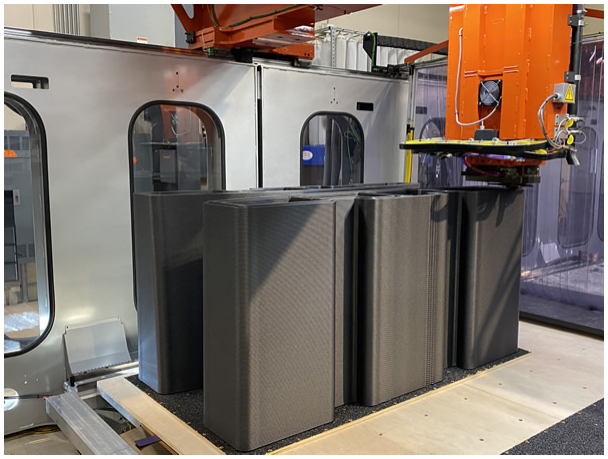
Horizontal Layer Printing (HLP). Standard printing from the machine table.

Vertical Layer Print (VLP) option. Vertical Layer Printing allows parts to be printed that are as long as the machine table.

Angle Layer Printing (ALP) option. Angle Layer Printing is the ability to print at a 45 degree angle.

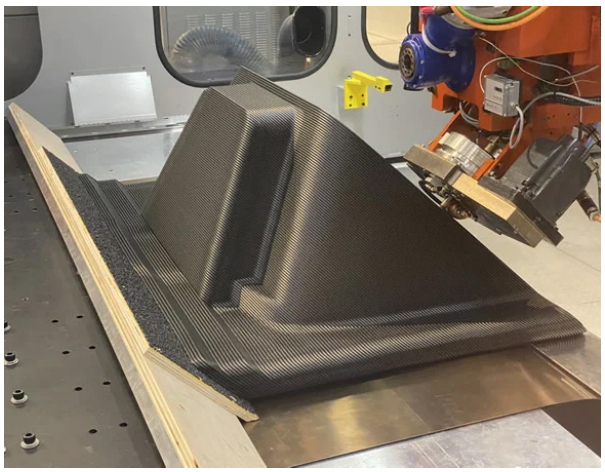
Each print orientation has advantages and limitations for a particular part design. Offering all three on the same machine, for the first time, means maximum print flexibility. All print orientations use the complete LSAM print head.

HLP-Horizontal Layer Printing



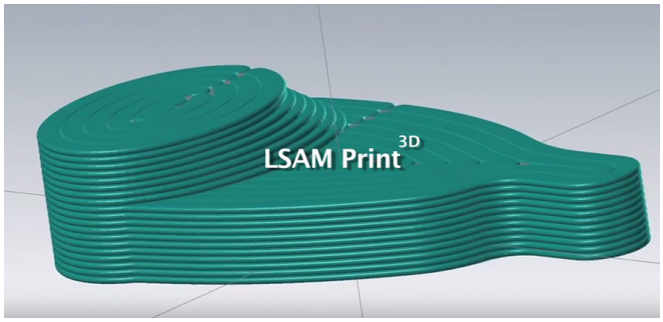
VLP- Vertical Layer Printing

ALP- Angle Layer Printing



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.

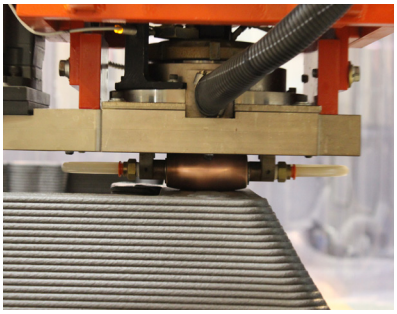
The 3D computer model is then used to generate a trim program which is used to trim the part using the trim gantry.

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.

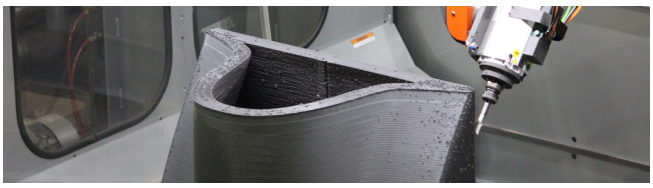
Printing

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.



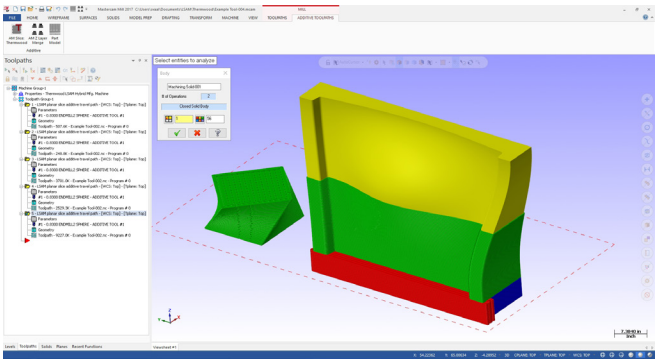
Trimming



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.

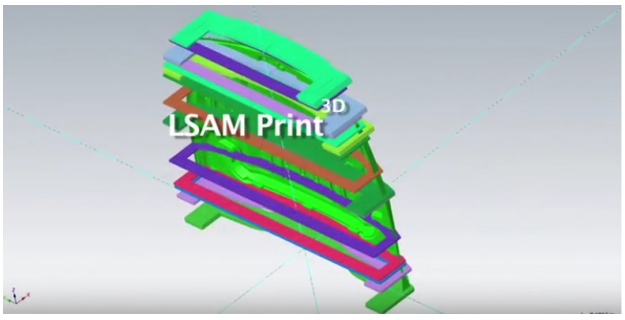
LSAM Printing Software



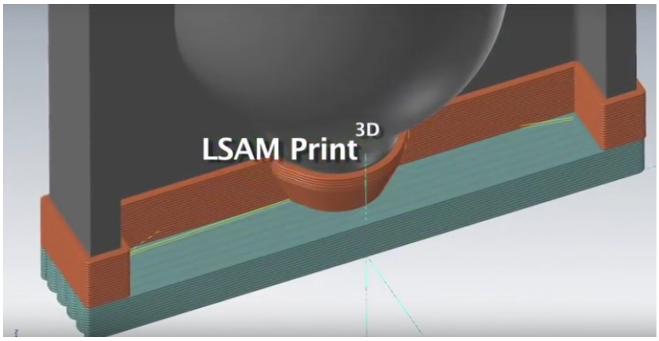
Most 3D printing software is designed for small machines that output a small bead in thin layers to print parts to the final net size and shape. Thermwood's approach is fundamentally different, so existing software doesn't work. LSAM machines use a "near-net-shape" approach where parts are printed layer 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.

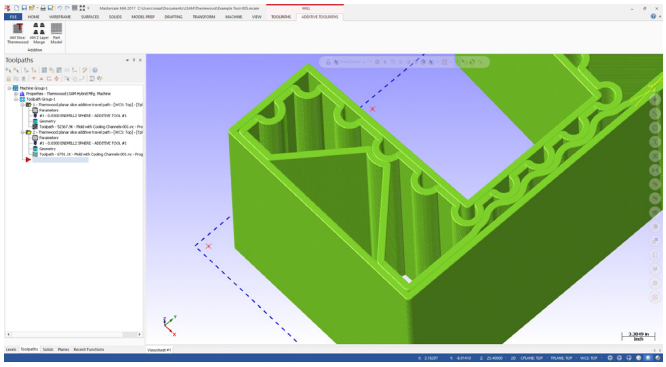


The 3D computer model, in an industry standard solid, surface or mesh file format, is loaded into Mastercam software and Thermwood's LSAM Print^{3D} utility is used to create a print model and generate the CNC machine code needed to actually print the part.



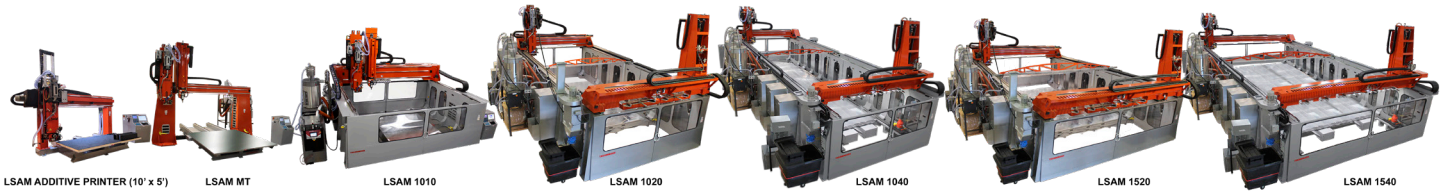
Then a CNC trim program is generated to trim the part to size.

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)	Moving 5 'x 5' (1.5m x 1.5m)	Moving 5'x 10' (1.5m x 3.0m)	Moving 10'x 5' (3.0m x 1.5m)	Moving 10'x 10' (3.0m x 3.0m)	Fixed 10'x 10' (3.0m x 3.0m)	Fixed 10'x 20' (3.0m x 6.0m)	Fixed 10'x 40' (3.0m x 12.0m)	Fixed 15'x 20' (4.5m x 6.0m)	Fixed 15'x 40' (4.5m x 12.0m)
Max Print Height	4' (1.2m)	4' (1.2m)	4' (1.2m)	5' (1.5m)	5' (1.5m)	5' (1.5m)	5' (1.5m)	5' (1.5m)	5' (1.5m)
Vertical Layer Print	N/A	Optional	N/A	Optional	N/A	Optional	Optional	Optional	Optional
Angle Layer Print (requires VLP)	N/A	N/A	N/A	N/A	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	Yes	Yes	Yes	Yes
Available Print Heads	40mm	40mm	40mm	40mm	40mm	40mm Standard	40mm Standard	40mm Standard	40mm Standard
Max Print Rate (lbs/hr) Polymer Dependent	up to 200 (90 kg)	up to 200 (90 kg)	up to 200 (90 kg)	up to 200 (90 kg)	up to 200 (90 kg)	up to 200 (90 kg)	up to 200 (90 kg)	up to 200 (90 kg)	up to 200 (90 kg)
Max Part Weight (lbs)	1,000lb (454 kg)	Standard Print 1,000lb (454 kg) Vertical Print 2,000lb (907 kg)	Standard 1,000lb (454 kg) 2,000lb (907 kg) (w/Opt 2nd Drive)	5,000lb (2268 kg)	Stanard- No Practical Limit	Standard- No Practical Limit Verticle Print- 50,000lb (22,680 kg)	Standard- No Practical Limit Vertical Print- 50,000lb (22,680 kg)	Standard- No Practical Limit Vertical Print- 50,000lb (22,680 kg)	Standard- No Practical Limit Vertical Print- 50,000lb (22,680 kg)
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

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