Welcome to PADT's online 3D Printing Glossary, the Downloadable Version. The glossary is a place to find definitions for the terms used in the Additive Manufacturing industry.

It is by no means authoritative nor complete, but we hope you find it helpful. It is our take on the words used in the industry, based on our activity in that industry since the mid-1990s. We hope it will grow into a larger and more comprehensive glossary as time passes.

For the latest, and the form to suggest new terms to cover, please visit:

www.3dprinting-glossary.com

You can learn more about PADT at:

www.padtinc.com

3D Printing

The act of creating a part using Additive Manufacturing. Originally 3D Printing referred to the user of smaller, less expensive, and less capable additive manufacturing systems. It has now become a synonym for Additive Manufacturing and has become the more common term used by the general public and non-industry media.

3D File

A computer file with three-dimensional information stored inside that defines the shape of a physical part or parts. 3D files are used in additive manufacturing to define what geometry the printer will print. Many formats are available.

3D Printer

A common term for an Additive Manufacturing System. Originally defined as a lower cost, smaller, and less capable class of Additive Manufacturing systems, the term is now used more often outside of engineering and manufacturing.

3SP

A vat photopolymerization process that uses a moving laser assembly. The process moves the laser in the Y-direction while scanning very quickly in the X-direction, solidifying each layer of photopolymer with the laser's ultraviolet beam. It is very similar to stereolithography, which uses a stationary laser assembly in both the X-direction and Y-direction. Abbreviated as 3SP.

3MF

An XML based file format used in additive manufacturing to define a part to be printed. As an alternative to STL format, it still uses facets to describe the part surface but also has support for color and texture specification, a way to efficiently describe lattice structures, and support for multiple materials. It is also extensible and other part characteristics can be included. Abbreviated as 3MF

3D Manufacturing Format

An XML based file format used in additive manufacturing to define a part to be printed. As an alternative to STL format, it still uses facets to describe the part surface but also has support for color and texture specification, a way to efficiently describe lattice structures, and support for multiple materials. It is also extensible and other part characteristics can be included. Abbreviated as 3MF

4D Printing

The creation of parts that change shape over time. The shape change is often activated by a change in temperature or moisture. Such parts are sometimes called self-assembled parts.

Abrasive Blasting

A process where small particles are propelled through a nozzle with compressed air over the surface of a part to smooth a rough surface.

Abrasive Flow Machining

A post-processing method where a viscous Abrasive Fluid flows around the surfaces of a manufactured. In additive manufacturing, it is one of the preferred ways to improve the surface finish of internal features. Abbreviated as AFM.

Abrasive Fluids

A fluid that contains fine, abrasive particles. The fluid is used in Abrasive Flow Machining to smooth surfaces and is one of the only ways to improve the surface finish of internal features on a part created with additive manufacturing.

ABS

Acrylonitrile Butadiene Styrene is an opaque thermoplastic polymer. Acrylonitrile Butadiene Styrene is easily machined, sanded, painted, or glued. It has a high strength, stiffness, and melting temperature. It also has good chemical resistance. Because it can be easily melted and formed, it is popular with injection molding and additive manufacturing. For additive manufacturing, it is most commonly formed into a filament, wrapped onto a spool, and used in FDM/FFF machines. Abbreviated as ABS.

Accuracy

A measure of how true or correct something is. In additive manufacturing, it is usually a measure of how closely the resulting dimensions on a part match the desired dimensions. It can also refer to the deviation of the tool path used to deposit, solidify, bond, etc... from the ideal path.

Acetone

An organic chemical with the formula (CH3)2CO. It is a solvent that is used in additive manufacturing in a process called vapor smoothing to remove stair steps on polymer parts.

ACIS File

A 3D file format used by the ACIS geometry kernel, one of the most popular commercial kernels used in CAD systems. Considered a neutral file format, it is a boundary representation of the geometry. It uses the .SAT (ASCII) and .SAB (Binary) file extensions.

Acrylic

A transparent thermoplastic engineered polymer. It is also called acrylic or acrylic glass and may go by the brand names of Plexiglas, Acrylite, Lucite, and others. It is strong, impact-resistant, and UV-resistant. In additive manufacturing, PMMA is used as a stock material in material extrusion processes and as a powder in binder jetting and powder bed fusion. Although acrylic materials can not be used as

a photopolymer needed in material jetting and vat photopolymerization, several acrylic-like materials have been developed for those processes.

Acrylonitrile Butadiene Styrene

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Acrylonitrile Styrene Acrylate

Acrylonitrile Styrene Acrylate is an opaque thermoplastic polymer developed as an alternative to ABS. Like ABS, it is easily machined, sanded, painted, or glued. It has a high strength, stiffness, and melting temperature. It also has good chemical resistance. It offers three improvements over ABS: improved mechanical properties, better aesthetics, and UV resistance. Because it can be easily melted and formed, it is popular with injection molding and additive manufacturing. For additive manufacturing, it is most commonly formed into a filament, wrapped onto a spool, and used in FDM/FFF machines. Abbreviated as ASA.

Additive Layer Manufacturing

The process of manufacturing a part by adding layers of material on top of the previous layer. It is rarely used, and additive manufacturing or 3D Printing are the more common terms used, although additive layer manufacturing is more precise for most additive manufacturing processes. Abbreviated as ALM.

Additive Manufacturing

Additive manufacturing is the industry-accepted term (ASTM F2792) for all manufacturing processes that make physical objects by adding material, as opposed to subtractive manufacturing where material is removed. It is a subset of free form fabrication. Abbreviated as AM.

Additive Manufacturing File Format

A file format used in most additive manufacturing processes. It is a faceted representation of the geometry that is easy to slice. The format was developed as a replacement of the STL file format. Like STL files, it uses a faceted representation of triangles to define the surface of a part. Unlike the

STL format, it can specify curved triangles and can include material and color information. Defined by ISO/ASTM 52915. It is abbreviated as AMF

Additive Manufacturing Machine

A machine used to produce physical parts using additive manufacturing.

Additive Manufacturing System

A machine used to produce physical parts using additive manufacturing.

Additive System

The ASTM recognized general term for additive manufacturing machines, additive manufacturing systems, additive manufacturing equipment, and any accessory equipment used in additive manufacturing.

Adhesion

A measurement of the tendency for two surfaces to cling to each other. In additive manufacturing, it may refer to the strength of the bond between two build layers, or it may refer to the strength of the bond between a part and the build platform or build plate.

Aerogel

A family of ultralight and porous materials made from a gel that is infused with gas before it hardens, resulting in a complex structure that is mostly porous. They can be made from a variety of chemical compounds.

AFM

A post-processing method where a viscous Abrasive Fluid flows around the surfaces of a manufactured. In additive manufacturing, it is one of the preferred ways to improve the surface finish of internal features. Abbreviated as AFM.

ALM

The process of manufacturing a part by adding layers of material on top of the previous layer. It is rarely used, and additive manufacturing or 3D Printing are the more common terms used, although additive layer manufacturing is more precise for most additive manufacturing processes. Abbreviated as ALM.

Alumide

A polymer material consisting of nylon with aluminum dust filler. It is used in selective laser sintering additive manufacturing systems. The resulting parts have high stiffness, better thermal conductivity, and higher temperature performance when compared to other nylon-based materials.

AM

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AMF

A file format used in most additive manufacturing processes. It is a faceted representation of the geometry that is easy to slice. The format was developed as a replacement of the STL file format. Like STL files, it uses a faceted representation of triangles to define the surface of a part. Unlike the STL format, it can specify curved triangles and can include material and color information. Defined by ISO/ASTM 52915. It is abbreviated as AMF

Amorphous

Refers to a type of material where the arrangement of the atoms has no periodic structure. It is the opposite of crystalline material. The lack of a periodic atomic structure drives the bulk material properties. In additive manufacturing, some metal processes use amorphous alloys, creating parts that area harder, have higher strength, and resist corrosion when compared with alloys that have a crystalline microstructure.

Anisotropic

Refers to material properties that are different in every direction. As opposed to isotropic, the same in all directions; or to orthotropic, different along orthogonal directions.

Area Printing

A form of powder bed fusion where an area is exposed to laser energy on the surface of the powder bed, rather than tracing a beam. Four steps are used to sinter the build layer. First, a powerful, pulsed laser beam is spread into a square area. Second, a projector sends blue light in the pattern of the area to be sintered in parallel with the column of laser light. Third, a polarization device is used to polarize any photons that are not a mixture of blue and laser light. Fourth, the polarized light is split off and deflected away,

allowing the unpolarized light, in the shape of the area to be sintered, to heat and sinter the top layer of the powder bed. The build square is moved across the surface until the layer is completed, the build plate is lowered, and a new layer of powder is spread across the top. This process is repeated for each layer. This approach is similar to Diode-based Additive Manufacturing, but delfects instead of dims the laser light in non-printing regions. It can also projects over a smaller area.

As Built

A description of a part that captures the actual geometry and non-graphical attributes that exist in the real world part. Determined by inspection and scanning, as built is used to specify the actual part configuration as opposed to the desired, or as designed configuration.

As Designed

A description of a part that captures the desired geometry and non-graphical attributes that manufacturing attempts to realize in the finished part. Specified as part of the design process, as designed is used to specify the desired part configuration as opposed to the real world, or as built configuration that results from manufacturing.

ASA

Acrylonitrile Styrene Acrylate is an opaque thermoplastic polymer developed as an alternative to ABS. Like ABS, it is easily machined, sanded, painted, or glued. It has a high strength, stiffness, and melting temperature. It also has good chemical resistance. It offers three improvements over ABS: improved mechanical properties, better aesthetics, and UV resistance. Because it can be easily melted and formed, it is popular with injection molding and additive manufacturing. For additive manufacturing, it is most commonly formed into a filament, wrapped onto a spool, and used in FDM/FFF machines. Abbreviated as ASA.

ASCII

American Standard Code for Information Interchange (ASCII) is a standard that assigns numbers to text characters. It is how text is stored in computer files. In additive manufacturing, it refers to a text file, as opposed to a file where data is stored in binary format.

Assembly

A collection of parts that are connected to one another in some way.

ASTM Additive Manufacturing Processes

Seven standard classifications for additive manufacturing processes established by ASTM and ISO standards committees in EN ISO/ASTM 52900:2015. All current additive manufacturing processes fit into one of the seven categories. The seven categories are: Binder JettingDirected Energy DepositionMaterial ExtrusionMaterial JettingPowder Bed FusionSheet LaminationVat Photopolymerization

Axis Binding

A problem associated with inexpensive desktop printers when the x-, y, or z-axis is not able to move freely. It can be caused by misalignment, material in the linear bearings or the actuator, or a problem with the linear actuator.

BAAM

A type of material extrusion additive manufacturing where polymer pellets, the same raw material used in injection molding, are melted, then fed into a heated extruder and deposited on the current build layer. It varies from FDM/FFF in size of the build volume, the diameter of the nozzle, and use of pellet material instead of filament. These systems utilize large industrial gantries and material handling equipment from injection molding to position and feed material to the extruder. The build volume size is only limited by the size of the gantry used. It is often utilized to create large tools and molds or large structures. Abbreviated as BAAM.

Ballistic Particle Manufacturing

A type of material jetting additive manufacturing where melted polymer or wax is jetted from an inkjet nozzle onto the build layer. Abbreviated as BPM.

Batch

The output of a single manufacturing run where the end product has the same characteristics. In additive manufacturing, it usually refers to a manufacturing run that produces feedstock with identical mechanical properties. It may also refer to a single run in an additive manufacturing machine where multiple parts are created.

Bead Blasting

A form of abrasive blasting where small spherical particles are propelled through a nozzle with compressed air to smooth a rough surface. Gentler than grit blasting because the particles are smooth and softer.

Beam Diameter

The diameter of the laser or electron beam used in additive manufacturing methods. The beam diameter is the smallest feature size in the X-Y plane. It also determines the amount of material melted or solidified as the beam moves over the build layer. The term may apply to other additive manufacturing methods that utilize a beam of some kind.

Bed

In non-powder based additive manufacturing systems, the surface that the part is created on, another term for build plate. In powder-based systems, the flat volume of powder that the part is built within.

Belt Drive

A mechanical system that transfers motion between two or more shafts via a flexible belt that is wrapped around a wheel on each shaft. The belt and wheels can have teeth or be smooth. A belt drive can be sued to convert rotational motion to linear motion by attaching an object to the belt between the wheels. In additive manufacturing, a belt drive is often attached to a stepper motor and part of the carriage mechanism is attached to the belt, providing precise linear motion along a single axis. Low-cost additive manufacturing systems often use belt drives rather than more expensive but faster and more accurate screw drives.

Big Area Additive Manufacturing

A type of material extrusion additive manufacturing where polymer pellets, the same raw material used in injection molding, are melted, then fed into a heated extruder and deposited on the current build layer. It varies from FDM/FFF in size of the build volume, the diameter of the nozzle, and use of pellet material instead of filament. These systems utilize large industrial gantries and material handling equipment from injection molding to position and feed material to the extruder. The build volume size is only limited by the size of the gantry used. It is often utilized to create large tools and molds or large structures. Abbreviated as BAAM.

Binary

The representation of data as ones and zeros. In additive manufacturing, it usually refers to a file that cannot be read by humans. A binary file is not a text file.

Binder

Material used to chemically bond particles together. The binder may be sprayed, jetted, or activated with heat or light.

Binder Jetting

Any additive manufacturing process that uses a binder to chemically bond powder where the binder is placed on the top layer of powder through small jets, usually using inkjet technology. One of the defined standard categories of ASTM additive manufacturing processes. Abbreviated as BJT.

Biomimicry

Utilizing the structures, processes, and growth found in nature to inform and influence the design of man-made objects and systems.

Biopolymer

Polymer materials that are created by living organisms or from raw materials that are created by living organisms. In additive manufacturing, PLA is a biopolymer made from fermented plant starches.

Bioprinter

An additive manufacturing system that produces parts which contain living tissue or tissue-like structures. Bioprinters can use a variety of additive manufacturing processes and sometimes include simple actuated syringes that deposit biomaterials with a range of viscosities on polymers.

Bioprinting

Using additive manufacturing to produce parts that contain living tissue or tissue-like structures.

BJT

Any additive manufacturing process that uses a binder to chemically bond powder where the binder is placed on the top layer of powder through small jets, usually using inkjet technology. One of the defined standard categories of ASTM additive manufacturing processes. Abbreviated as BJT.

Bottom Curing System

A subset of vat photopolymerization where the ultraviolet curing light is projected or traced on the transparent bottom of the vat. Each layer is created on the bottom and the part is raised up and out of the vat, creating the part upside down when compared to a top curing

system like Stereolithography devices. A bottom curing system needs only to have enough photopolymer material to create the part whereas a top curing system must fill the entire build volume with material.

Boundary Representation Geometry

Boundary representation geometry (B-Rep) is a method for representing shapes that defines the limits of the shapes. Solids are represented as a collection of connected 3D surfaces that sit on the boundary between solid and non-solid. B-Rep geometry also usually includes 3D curves that define the edges of surfaces and points that define vertices.

Bounding Box

The smallest rectangular prism that a given part can fit. It is usually aligned with the parts coordinate system or the additive manufacturing machines axis.

Bowden Extruder

A type of extruder used in fused deposition modeling where the gear drive that pushes the filament into the heater and through the nozzle is fixed to the frame of the additive manufacturing system and separate from the heater and nozzle that are in the print head, which moves to create the build layer. A Teflon tube is usually used to connect the drive gear to the print head, allowing the drive gear to push the filament without causing it to buckle. The opposite of a Bowden extruder is a direct drive, where the drive gear is located next to the heater and nozzle in the print head.

BPM

A type of material jetting additive manufacturing where melted polymer or wax is jetted from an inkjet nozzle onto the build layer. Abbreviated as BPM.

Breakaway Support Material

A type of support material that is rigid and separates from the build material by applying a gentle force through a manual process.

Breakout Station

A piece of post-processing equipment that is used to remove parts from a block of powder created as part of a powder bed fusion or binder jetting additive manufacturing process. The breakout station may be included or open at the top. It usually includes some sort of powder management system and takes into account the health and safety issues of dealing with both polymer and metal powders.

Bridging

Depositing layers of unsupported material across an air gap. Mostly used in material extrusion (MEX) systems that do not have a support material option. Bridging a gap at to shallow of an angle will often cause the build to fail or the part to sag.

Brim

The first layer of material in a build that is solid and extends outside of the part, but not under the part. It is used in lower-cost systems where the part is attached to a build plate to improve adherence of the part to the build plate. An alternative to using a raft or a skirt.

Brown Part

In sintering, a part that is made of chemically bound and compressed powdered material is called a green part. A brown part is created when a green part has been heated and/or chemically treated to remove the binder that previously held the powder together. The brown part is then further heated to fully sinter the part.

Build Area

The area on a build plate, the top level of a vat, or the top layer of powder where parts can be safely built.

Build Chamber

The enclosed volume within an additive manufacturing system where the part is constructed.

Build Coordinate System

The coordinate system the defines the orientation and build volume in an additive manufacturing system. May be aligned with or defined relative to the machine coordinate system.

Build Cycle

A single run of the build process in an additive manufacturing system from start to part removal.

Build Direction

The direction on a part perpendicular to the layers.

Build Envelope

The maximum physical size of a part that can be built in a given additive manufacturing system. Usually specified as the maximum length, width, and height. Also called build volume.

Build Height

The maximum dimension of the part perpendicular to the build plane. The build height determines the number of layers.

Build Layer

The layer of material that is being constructed by an additive manufacturing system at any given time. The build layer is the layer of material is being cut, deposited, bound, etc.

Build Material

The material that the part is built from. Also referred to as model material. Other materials used may be considered binder or support material.

Build Origin

The reference point in the build volume where the build coordinate system is centered. It is defined by the additive manufacturing systems software and can be moved in most systems.

Build Parameters

The set of process parameters used for a particular build in an additive manufacturing system

Build Plate

A horizontal plate that is used in many additive processes where the first layer is attached. May also be called the build platform.

Build Platform

A horizontal plate that is used in many additive processes where the first layer is attached. May also be called the build plate.

Build Space

The area within an additive manufacturing system where parts are constructed. A volume within the build chamber for enclosed systems or on the build platform for non-enclosed systems.

Build Surface

The surface upon which the current build layer is created on. It is usually the previous build layer or, for the first layer, the build plate or an existing part for direct energy deposition. Build surface can also refer to the surface that the first layer is built upon in material extrusion systems and is often a film or tape applied to the top of the build plate.

Build Time

The amount of time used to create a part from the start of the first layer to the completion of the last layer. Usually preceded by warm-up time and cool-down time.

Build Volume

The volume of a part being built including any additional geometry added to the desired final part. Does not include the support volume if supports are made from a different material.

CAD

Computer Aided Design refers to the digital definition of single objects or multiple objects. The abbreviation, CAD, is used more often than the full term. CAD software is used to define geometry, topology, and non-geometric attributes for objects.

CAD File

The computer file that stores the digital definition of a single object or multiple objects.

Caking

When powder in a powder bed fusion or binder jetting application adheres to create a clump of material lodged on the surface of or inside features in the part. Caking can happen in holes and pockets. Time and care must be used in post-processing to loosen the powder and remove it from the part.

Calibration

The process of ensuring the location and dimension of parts and sensors in a system are known and consistent. In additive manufacturing, calibration determines the position of various components and how they move with a given signal. It may be measuring and adjusting the strength of a laser beam or the position of a deposition nozzle. All

components and sensors require calibration to ensure the accuracy of the parts being created.

CAM

Manufacturing that uses computers to numerically control the precise motion of machines. Strictly speaking, additive manufacturing is computer aided manufacturing. But usually, the term is used to refer to numerically controlled subtractive manufacturing or forming.

Carriage

A structure in a machine that carries something through space. In additive manufacturing, it usually refers to a mechanical subassembly that precisely moves a print head, material smoother, or build platform along the x-, y-, and/or z-axis.

Cartridge

A sealed container used to hold material used in additive manufacturing. A cartridge can hold a spool of filament, liquid, or powder. Cartridges are used to easily add material to a system instead of loading a spool, pouring liquid, or adding loose powder.

Centrifugal Barrel Finishing

A method used to smooth the surface of a manufactured part. It is a form of tumbling, where the part or parts are placed in a barrel that is filled with various abrasive materials. It varies from standard tumbling in that there are two to four barrels that rotate around an axis at high speed, causing the barrels to sping in the opposite direction. This causes high loading and pressure in the drums as well as significant movement of the abrasive material. In additive manufacturing, it is a common post-processing method for smoothing the surface of metal parts that can survive the high loads.

Ceramic

A type of material that is an inorganic, non-metallic carbide, nitride, or oxide material. Ceramic materials have high surface hardness, are brittle, and are stiff. They also have high strength in compression but are relatively weak in shear and mentions. They withstand most strong chemicals and hold their properties at high temperatures. Most ceramics parts are made by compressing ceramic powder or by binding ceramic powder and then sintering it. Additive manufacturing can be used to create the green part.

Ceramic Injection Molding

A form of injection molding where a fine ceramic powder, mixed with a binding material, is injected into the mold to create a brown part. That part then goes through debonding to produce a green part. The green part is then sintered. Although not an additive manufacturing process, additive manufacturing can be used to create the tooling used. It is also of interest to those using additive manufacturing processes to create a ceramic brown part since the follow-on steps and the design limitations are similar. Very similar to metal injection molding, except ceramic powder is used instead of metal powder. Abbreviated as CIM.

Cermet

A material made of both ceramic (cer) and metal (met), providing the unique combination of high hardness and toughness. The metal material is used as the binder and the ceramic as the reinforcing material. In additive manufacturing, powder bed fusion, direct energy deposition, binder jetting, and material extrusion can be made to create the cermet parts.

Chassis

The rigid, static portion of a machine. Also referred to as the frame.

Chopped Fiber

A form of composite material where fibers are cut up into small pieces and mixed in with a polymer. Commonly used in injection molding, it can also be used in additive manufacturing where the fibers are added to the build material. Glass and carbon fibers are the most common additives.

Chord Height

When using faceted geometry, the maximum distance from the planar surface of the facet to the actual curved surface defined in the CAD geometry is the chord height. It is a measure of the precision of the faceted representation.

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manufacturing processes to create a ceramic brown part since the follow-on steps and the design limitations are similar. Very similar to metal injection molding, except ceramic powder is used instead of metal powder. Abbreviated as CIM.

CLIP

A type of vat photopolymerization additive manufacturing where a projector under a transparent build plate shines ultraviolet light onto the build layer, which is against the transparent build plate. The part is then pulled upward so that a new layer of liquid fills between the build plate and the part, and the process is repeated. It is a continuous build process that does not create distinct layers. It is a proprietary process owned by the company Carbon and the term has been replaced by Carbon with Digital Light Synthesis, or DLS. Abbreviated as CLIP.

CMB

A hybrid manufacturing process that combines directed energy deposition additive manufacturing with subtractive machining to create accurate metal parts. It usually involves a controlled metal spray or controlled wire welding to deposit a layer of metal material on the build layer. Then a high-speed milling cutter is used to smooth the outside surface or create desired features in the part. Abbreviated as CMB

CMB File

A file format used in fused deposition modeling that contains g-code that drives Stratasys FDM systems. The file consists of machine motion instructions and build parameters for each layer. It is created by slicing software. Abbreviated as CMB File.

CNC

Computerized numerical control refers to the control of a manufacturing machine by a computer. A program or a script tells the machine what to do over time. The opposite of computerized numerical control is manual machining. Abbreviated as CNC.

Composite Material

Any material made up of two or more materials with different physical and chemical properties and where the different materials remain separate after being combined. Most additive manufacturing processes have the ability to use composite materials or to create composite materials during the build process.

Compressed File

A computer file that has been reduced in size through an algorithm that can be reversed to recreate the original file.

Computed Tomography Scan

A form of scanning that measures the external and internal geometry of an object using a series of planer x-ray images. These x-ray images are stacked to create a 3D model that can be viewed and precisely measured. Formerly referred to as a CAT scan. In additive manufacturing, it is used as a non-destructive inspection method to view internal features in a part, especially voids in parts made with metal powder bed fusion. Abbreviated as CT.

Computer Aided Design

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Computer Aided Manufacturing

Manufacturing that uses computers to numerically control the precise motion of machines. Strictly speaking, additive manufacturing is computer aided manufacturing. But usually, the term is used to refer to numerically controlled subtractive manufacturing or forming.

Computerized Numerical Control

Computerized numerical control refers to the control of a manufacturing machine by a computer. A program or a script tells the machine what to do over time. The opposite of computerized numerical control is manual machining. Abbreviated as CNC.

Conformal Cooling

Placing cooling passages inside a manufacturing mold or pattern that follows the surface of the tool that shapes the part. It is used to more efficiently control the temperature on the surfaces that contact the part being created. In additive manufacturing, the free-form nature of layered construction enables the easy creation of conformal cooling.

Continuous Fiber

A form of Material Extrusion where a thread of carbon fiber or glass is fed through the center of the extrusion nozzle as a part is built. This results in

a continuous fiber capture inside the hardened polymer extruded by the machine, adding stiffness and strength. In some processes, the fiber is embedded into the build material filament when the filament is manufactured. In others, it is added to the polymer after the filament is melted in the extruder, and in others, the fiber is covered in polymer before it is heated and extruded.

Continuous Liquid Interface Production

A type of vat photopolymerization additive manufacturing where a projector under a transparent build plate shines ultraviolet light onto the build layer, which is against the transparent build plate. The part is then pulled upward so that a new layer of liquid fills between the build plate and the part, and the process is repeated. It is a continuous build process that does not create distinct layers. It is a proprietary process owned by the company Carbon and the term has been replaced by Carbon with Digital Light Synthesis, or DLS. Abbreviated as CLIP.

Controlled Metal Buildup

A hybrid manufacturing process that combines directed energy deposition additive manufacturing with subtractive machining to create accurate metal parts. It usually involves a controlled metal spray or controlled wire welding to deposit a layer of metal material on the build layer. Then a high-speed milling cutter is used to smooth the outside surface or create desired features in the part. Abbreviated as CMB

Cool Down

The length of time that it takes for an additive manufacturing machine to reach its recommended safe temperature to access the build area and remove parts. This could be the temperature of the build plate, the air in the chamber, the powder bed, or various components.

Coordinate Machine Binary

A file format used in fused deposition modeling that contains g-code that drives Stratasys FDM systems. The file consists of machine motion instructions and build parameters for each layer. It is created by slicing software. Abbreviated as CMB File.

Copolymer

A polmer that consists of two or more different monomers linking in the same polymer chain. A polymer chain with a single monomer is called a homopolymer. Many polymers used in additive manufacturing are copolymers.

Cross-Link

A chemical bond of one polymer chain to another.

Crystalline

Refers to a type of material where the arrangement of the atoms has a periodic structure. It is the opposite of amorphous material. The periodic atomic structure drives the bulk material properties. In additive manufacturing, some metal processes result in parts with a crystalline microstructure. Post-processing is used to remove or optimize that structure.

CT

A form of scanning that measures the external and internal geometry of an object using a series of planer x-ray images. These x-ray images are stacked to create a 3D model that can be viewed and precisely measured. Formerly referred to as a CAT scan. In additive manufacturing, it is used as a non-destructive inspection method to view internal features in a part, especially voids in parts made with metal powder bed fusion. Abbreviated as CT.

Cupping

A failure mode in vat photopolymerization additive manufacturing processes where the build surface is on the bottom of the vat. If the part geometry creates a traped volume of build material between the part and the build surface, it can create a negative pressure that causes the sides of the part to be pulled inward, distorting or even breaking the part.

Cure

To harden a polymer part using a chemical reaction. See curing.

Cure Temperature

The temperature at which a temperature cured polymer resin cross-links to form a hard material.

Curing

A chemical process where the molecules in a liquid resin cross-link to create a hard polymer. Many additive manufacturing processes use the curing process to convert a liquid to a solid on a given layer. Curing can be caused by light in a photopolymer, heat, chemical reactions, or time.

d-Limonene

A chemical derived from the oil in citrus fruit. It is used as a dietary supplement, fragrance, food-manufacturing, flavoring, insecticide, herbicide, solvent, and cleaning products. In additive manufacturing, it is used as a solvent to remove high-impact polystyrene (HIPS) when used as a support material. Sometimes referred to as Limonene.

Datum

A plane, axis, or point on an object that is used as a reference location for measuring distances or angles to other features on the object and the tolerance of those distances or angles.

De-Binder

A device that is used to remove binding material from a part. Heat or chemicals are usually used.

DED

An additive manufacturing process where metal powder is jetted or wire is extruded from a CNC controlled three or five axis nozzle. The solid material is then melted by an energy source, usually a laser or electron beam, such that the liquid metal deposits onto the previous layers (or build plate) and then cools to a solid. One of the defined standard categories of ASTM additive manufacturing processes. Abbreviated as DED.

Delamination

When the layers of an additive manufacturing part separate from one another.

Depowdering

A post-processing step for powder bed fusion or binder jetting additive manufacturing processes where loose powder is removed from the part. This includes removing loose and caked powder from features and removing powder from the surface. This process can be manual, using compressed air, water, and/or a brush or it can be automated using vibration, compressed air, and/or water. This step is often started in a breakout station.

Design for Additive Manufacturing

The process of consciously including the advantages and disadvantages of various additive manufacturing processes in the design of a part to avoid the disadvantages and utilize the advantages. The purpose of DfAM is to reduce

the cost of additive manufacturing a given part, reduce scrap, and increase part performance including durability, accuracy, and aesthetics.

Desktop 3D Printing

A subset of additive manufacturing that refers to smaller, less expensive machines that are small and light enough to operate on a standard table.

DfAM

The process of consciously including the advantages and disadvantages of various additive manufacturing processes in the design of a part to avoid the disadvantages and utilize the advantages. The purpose of DfAM is to reduce the cost of additive manufacturing a given part, reduce scrap, and increase part performance including durability, accuracy, and aesthetics.

DiAM

A powder bed fusion additive manufacturing process that uses an array of high-powered pulse laser diodes to expose the entire top layer. A combination of a blue light LCD projector and customized laser modulator creates a 2D pattern that selectively lowers the energy of the projected laser light where melting is not wanted for that layer. The build plate then lowers, a new layer of powder is smooth across the top, and the process is repeated. This method is much faster than laser powder bed fusion because the entire build surface is exposed at one time, rather than using a raster pattern. This approach is similar to area printing but dims instead of deflects the laser light in non-printing regions. It can also project over a larger area. Abbreviated as DiAM.

Digital Light Processing

A projection technology that utilizes an array of microscopic mirrors arranged on a microchip to reflect a specific pattern of light through a lens. Each mirror represents a pixel, and light is projected onto the chip and a controller is used to flip each mirror to either deflect light for a given pixel through a lens or away from a lens. This provides a very sharp and accurate image. The technology is common in projectors used in movie theaters, home theaters, and meeting rooms. In additive manufacturing, Digital Light Processing projectors can be used instead of a laser to project ultraviolet light in a very accurate and precise pattern for vat photopolymerization and some binder jetting applications where a photopolymer is used as the binder. Abbreviated as DLP.

Digital Light Synthesis

A type of vat photopolymerization additive manufacturing where a projector under a transparent build plate shines ultraviolet light onto the build layer, which is against the transparent build plate. The part is then pulled upward so that a new layer of liquid fills between the build plate and the part, and the process is repeated. Digital light synthesis is a continuous build process that does not create distinct layers. Abbreviated as DLS.

Digital Material

The material in a part that is created by mixing multiple base materials as each layer of the part is created. The mix of materials, and therefore the material properties, can vary across a given layer from layer to layer. Digital materials allow the creation of very specific material properties when a part is being built.

Digital Sculpting

The manipulation of CAD geometry by pushing, pulling, or cutting surfaces in a way that replicates the manual sculpting of material in the real world. Some feel this is a more intuitive and artistic way to modify geometry compared to bottom-up, feature-based, or Boolean geometry creation and manipulation.

Diode-based Additive Manufacturing

A powder bed fusion additive manufacturing process that uses an array of high-powered pulse laser diodes to expose the entire top layer. A combination of a blue light LCD projector and customized laser modulator creates a 2D pattern that selectively lowers the energy of the projected laser light where melting is not wanted for that layer. The build plate then lowers, a new layer of powder is smooth across the top, and the process is repeated. This method is much faster than laser powder bed fusion because the entire build surface is exposed at one time, rather than using a raster pattern. This approach is similar to area printing but dims instead of deflects the laser light in non-printing regions. It can also project over a larger area. Abbreviated as DiAM.

Direct Drive

A type of extruder used in fused deposition modeling where the gear drive that pushes the filament into the heater and through the nozzle directly attached to the heater and nozzle in the print head, which moves to create the build layer. The opposite of a direct drive is a Bowden extruder, where

the drive gear is attached to the machine frame and does not move with the print head.

Direct Ink Writing

A material extrusion based additive manufacturing process that uses liquid ink extruded through a nozzle in a raster pattern, one layer at time. Almost any material can be printed if it can be converted, chemically or thermally, into a liquid. The process allows the largest variety of materials, including metals and ceramics, photopolymers, gels, and biomaterials. With multiple nozzles, multiple materials can be deposited on the same layer or on different layers. This process works well for nano-scale additive manufacturing as well as standard sizes. Abbreviated as DIW.

Direct Laser Melting

A type of powder bed fusion additive manufacturing where a laser beam is used to melt powder material. The beam is directed across the top layer of powder. The liquid material solidifies to create the desired part. A new layer of powder is placed on top, and the process is repeated. Also called laser powder bed fusion, or metal powder bed fusion. Abbreviated as DLM

Direct Metal Deposition

A form of directed energy deposition where a laser is used to melt metal powder that is ejected at high velocity from a heated nozzle. The nozzle traces a path and deposits the melted metal on the current build layer. Abbreviated as DMD.

Direct Metal Laser Melting

Another name for direct laser melting. Abbreviated as DMLM

Direct Metal Laser Sintering

Another name for direct laser melting. Abbreviated as DMLS

Direct-Write

A type of material jetting additive manufacturing where nanoparticles are atomized in an inert gas to deposit material in a thin layer. Because the layer is not flat, it is usually not used to create multi-layer geometry. This process is ideal for depositing a single layer of material with specific electrical properties onto existing geometry created with other additive manufacturing processes to create electrical circuits. It can also be mounted on a multi-axis positioning mechanism to produce a layer on a 3D surface and around corners.

Directed Energy Deposition

An additive manufacturing process where metal powder is jetted or wire is extruded from a CNC controlled three or five axis nozzle. The solid material is then melted by an energy source, usually a laser or electron beam, such that the liquid metal deposits onto the previous layers (or build plate) and then cools to a solid. One of the defined standard categories of ASTM additive manufacturing processes. Abbreviated as DED.

Distortion

Distortion is the deflection of a part from the shape created by the additive manufacturing process. The distortion can be caused by a variety of loads placed on or inside the part by the additive manufacturing process or the surrounding environment.

Distortion Compensation

A mathematical process where the distance from the as-built geometry to the CAD defined geometry is subtracted from the build geometry to create a new part definition that, when built, will more closely represent the desired dimensions.

DIW

A material extrusion based additive manufacturing process that uses liquid ink extruded through a nozzle in a raster pattern, one layer at time. Almost any material can be printed if it can be converted, chemically or thermally, into a liquid. The process allows the largest variety of materials, including metals and ceramics, photopolymers, gels, and biomaterials. With multiple nozzles, multiple materials can be deposited on the same layer or on different layers. This process works well for nano-scale additive manufacturing as well as standard sizes. Abbreviated as DIW.

DLM

A type of powder bed fusion additive manufacturing where a laser beam is used to melt powder material. The beam is directed across the top layer of powder. The liquid material solidifies to create the desired part. A new layer of powder is placed on top, and the process is repeated. Also called laser powder bed fusion, or metal powder bed fusion. Abbreviated as DLM

DLP

A projection technology that utilizes an array of microscopic mirrors arranged on a microchip to reflect a specific pattern of light through a lens. Each

mirror represents a pixel, and light is projected onto the chip and a controller is used to flip each mirror to either deflect light for a given pixel through a lens or away from a lens. This provides a very sharp and accurate image. The technology is common in projectors used in movie theaters, home theaters, and meeting rooms. In additive manufacturing, Digital Light Processing projectors can be used instead of a laser to project ultraviolet light in a very accurate and precise pattern for vat photopolymerization and some binder jetting applications where a photopolymer is used as the binder. Abbreviated as DLP.

DLS

A type of vat photopolymerization additive manufacturing where a projector under a transparent build plate shines ultraviolet light onto the build layer, which is against the transparent build plate. The part is then pulled upward so that a new layer of liquid fills between the build plate and the part, and the process is repeated. Digital light synthesis is a continuous build process that does not create distinct layers. Abbreviated as DLS.

DMD

A form of directed energy deposition where a laser is used to melt metal powder that is ejected at high velocity from a heated nozzle. The nozzle traces a path and deposits the melted metal on the current build layer. Abbreviated as DMD.

DMLM

Another name for direct laser melting. Abbreviated as DMLM

DMLS

Another name for direct laser melting. Abbreviated as DMLS

DOD

A material jetting additive manufacturing process that deposits droplets of material on the current build layer. Although most forms of material jetting are technically drop on demand, the term usually refers to systems that use larger droplet sizes to make molds and patterns. Abbreviated as DOD.

Drill Guide

A type of tooling used to control the location, angle, and depth of a hole or multiple holes. Additive manufacturing is often used to create drill guides for one-time or occasional use. Besides traditional manufacturing, 3D printed drill guides are commonly used in orthopedic and dental surgery.

Drop on Demand

A material jetting additive manufacturing process that deposits droplets of material on the current build layer. Although most forms of material jetting are technically drop on demand, the term usually refers to systems that use larger droplet sizes to make molds and patterns. Abbreviated as DOD.

Dual Extrusion

Refers to material extrusion systems with two extruders. This allows for two materials to be deposited on a build layer. This can be used to deposit material with different material properties or color. It is also used to deposit support material along with build material.

Dyeing

A process that applies pigments to a material to change the color of that material. It differs from painting in that the pigments are absorbed into the material being dyed, rather than existing as a coating on top of the material. In additive manufacturing, dyeing is used to change the color of parts after they are built.

EBM

A type of powder bed fusion additive manufacturing where an electron beam is used to melt powder material. The beam is directed across the top layer of powder. The liquid material solidifies to create the desired part. A new layer of powder is placed on top, and the process is repeated. Abbreviated as EBM

EDM

A form of subtractive manufacturing where a metal part is placed into a dielectric liquid and an electrode is placed very close to the part. A current is placed on the electrode and the part, and the current passes through the dielectric liquid, creating an electric arc. The electric arc erodes material from both the electrode and the part. The electrode is pushed into the part, removing material as it goes. The electrode can be a solid shape that is plunged into the part, creating a feature shaped like the probe, or a wire that is used to slice through the part. In additive manufacturing, wire EDM is often used to remove supports and the build plate from parts created with metal powder bed fusion. Abbreviated as EDM.

Elastomer

A type of polymer material that is both elastic and viscous, or viscoelastic. Elastomers are elastic because they distort when a load is applied but return to their original shape when the load is removed. They are viscous because they resist distortion when a load is applied. The term is a shortening of the term elastic polymer. Rubber and synthetic rubber are elastomers. Many additive manufacturing processes can create parts with elastomer materials with a variety of stiffnesses.

Electrical Discharge Machining

A form of subtractive manufacturing where a metal part is placed into a dielectric liquid and an electrode is placed very close to the part. A current is placed on the electrode and the part, and the current passes through the dielectric liquid, creating an electric arc. The electric arc erodes material from both the electrode and the part. The electrode is pushed into the part, removing material as it goes. The electrode can be a solid shape that is plunged into the part, creating a feature shaped like the probe, or a wire that is used to slice through the part. In additive manufacturing, wire EDM is often used to remove supports and the build plate from parts created with metal powder bed fusion. Abbreviated as EDM.

Electron Beam

A focused energy source consisting of a tight stream of high-energy electrons. In additive manufacturing, it is used to melt powder or wire metal, often used as an alternative to using a laser.

Electron Beam Melting

A type of powder bed fusion additive manufacturing where an electron beam is used to melt powder material. The beam is directed across the top layer of powder. The liquid material solidifies to create the desired part. A new layer of powder is placed on top, and the process is repeated. Abbreviated as EBM

Electrostatic Discharge Materials

Plastic materials that reduce static electricity. Abbreviated as ESD material.

Encrypted File

A computer file that has been encoded into a format that can only be accessed by authorized parties. An algorithm uses a process to encode the file and then decode it by someone with a key or password, called decryption. In additive manufacturing, files used to describe geometry may

be encrypted and need decryption to be pre-processed. Build files can also be encrypted after pre-processing and decrypted on the additive manufacturing system.

End Part

In additive manufacturing, end part refers to the object created after all post-processing and finishing is completed.

Endstop

An electro-mechanical switch used in machines to detect when a moving part has reached a certain position, and then send a stop signal. Also called a limit switch.

Epoxy

A polymer that starts as a liquid and turns into solid when cross-linking of the molecules in the material occurs, a process called curing. In additive manufacturing, polymers are deposited as a liquid as build material or binder.

ESD

Plastic materials that reduce static electricity. Abbreviated as ESD material.

Extruder

The device in a material extrusion system that heats, softens, and forces out the feedstock material being deposited by plastically deforming it. Sometimes referred to as an extruder head.

Extrusion

A manufacturing process where material is forced through a nozzle or die to create material in the shape of the nozzle or die.

Extrusion Multiplier

A build parameter for material extrusion systems that tells the machine how much material to extrude. It is a multiple of the standard or nominal flow rate.

Extrusion Nozzle

The standard term for a nozzle in a material extrusion system. Material is heated before the extrusion model then force is used to push the material through.

Facet

A polygon, usually three-sided, the vertices of which sit on the desired surface of an object. STL files, the most commonly used way to define a part in additive manufacturing, use facets to define the part's surfaces.

Faceted Geometry

Part geometry defined with facets as opposed to spline surfaces.

FDM

A type of material extrusion (MEX) additive manufacturing where a continuous filament of thermoplastic material is fed into a heated extruder and deposited on the current build layer. It is the trademarked name used for systems manufactured by the process inventor, Stratasys. Fused filament fabrication (FFF) is the generic term. Abbreviated as FDM

Feature

A collection of surfaces on an object or in the CAD representation of an object that define a recognized topology. As an example, a cylindrical hole, a pocket, a boss, a rib, or a keyway.

Feed Region

For powder bed fusion additive manufacturing systems, the region of a system where the powder is stored and from which material is moved to create the current build layer before fusing.

Feeder

In FDM/FFF, the motor and gearbox that pushes the filament towards the nozzle.

Feedstock

Any material that is used as input to a process that creates another material or a part. In additive manufacturing, the term is used to refer to material input into the system that ends up in the part produced.

FEP

A polymer that is similar to PTFE that melts at a low enough temperature to use in injection molding and other processes. It has low friction and is non-reactive. In additive manufacturing, FEP sheets are often used as a base to avoid adhesion between a part and the build surface in vat

photopolymerization. FEP filament can be used in fused deposition modeling. Abbreviated as FEP.

FEP Film

A thin sheet of fluorinated ethylene propylene (FEP) material used as a release layer for vat photopolymerization systems where the build layer is on the bottom of the vat. The FEP material has a low coefficient of friction and the build layer does not stick to it, allowing the part to be raised without sticking to the bottom of the vat, allowing the construction of the next layer.

FFF

A type of material extrusion (MEX) additive manufacturing where a continuous filament of thermoplastic material is fed into a heated extruder and deposited on the current build layer. It is the generic name used for systems not manufactured by the process inventor, Stratasys, which uses the term fused deposition modeling. Abbreviated as FFF.

FGF

A type of material extrusion (MEX) additive manufacturing where polymer pellets, the same raw material used in injection molding, are melted, then fed into a heated extruder, and deposited on the current build layer. It varies from most FDM/FFF systems in size of the build volume, the diameter of the nozzle, and use of pellet material instead of filament as feedstock. Also called Big Area Additive Manufacturing (BAAM). Abbreviated as FGF.

Filament

A long thread of material, cylindrical in cross-section. In additive manufacturing the filament is how the polymer material in FDM/FFF is delivered, usually on a spool or in a cartridge.

Fill Density

The percent of material, by volume, in an infill region. An 80% fill density would have 20% air and 80% build material. It may also refer to the percent of material by area on a given build area. May also be called Infill Density.

Film Transfer Imaging

A type of vat photopolymerization additive manufacturing where a projector under a transparent build plate shines ultraviolet light in the pattern to be solidified for that layer, onto the build layer, which is against the transparent build plate. The part is then pulled upward and a

deposition assembly travels across the transparent build plate and deposits a thin film of photopolymer. The part is then lowered until it is touching the newly deposited thin layer and the projector's lite selectively solidifies the new layer. Although considered vat photopolymerization, there is no vat or pool of liquid material. The material is actually a liquid film that is deposited onto the build plate one layer at a time. Abbreviated as FTI.

Fixture

A physical part or assembly used in manufacturing to hold a part or check the shape of a part. In additive manufacturing a fixture may be made with additive manufacturing or fixtures may be used in post-processing to hold parts during various processes. Different from a jig in that a jig guides or controls the motion or location of another tool. A fixture only holds the part or parts.

Flowable Metal Paste

A type of material extrusion (MEX) for metal additive manufacturing where a metal paste is deposited at room temperature on the current build layer. This produces a rough green part. The green part is then machined and then sintered to create a finished part with improved surface finish and feature accuracy when compared to most other material extrusion processes. Abbreviated as FMP.

Fluorinated ethylene propylene

A polymer that is similar to PTFE that melts at a low enough temperature to use in injection molding and other processes. It has low friction and is non-reactive. In additive manufacturing, FEP sheets are often used as a base to avoid adhesion between a part and the build surface in vat photopolymerization. FEP filament can be used in fused deposition modeling. Abbreviated as FEP.

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Frame

The rigid, static portion of a machine. Also referred to as the chassis.

Freeform Fabrication

The creation of solid parts directly from a computer model without the need for any molds or forms. Additive manufacturing is a subset of solid freeform fabrication where the material is added and no substantive processes are used. Sometimes referred to as only Freeform Fabrication.

Front

The side of the machine that the operator faces to access the user interface, the primary viewing window, or both.

FTI

A type of vat photopolymerization additive manufacturing where a projector under a transparent build plate shines ultraviolet light in the pattern to be solidified for that layer, onto the build layer, which is against the transparent build plate. The part is then pulled upward and a deposition assembly travels across the transparent build plate and deposits a thin film of photopolymer. The part is then lowered until it is touching the newly deposited thin layer and the projector's lite selectively solidifies the new layer. Although considered vat photopolymerization, there is no vat or pool of liquid material. The material is actually a liquid film that is deposited onto the build plate one layer at a time. Abbreviated as FTI.

Fully Dense

Refers to a part or a region in a apart where there are no significant voids in the material.

Fused Deposition Modeling

A type of material extrusion (MEX) additive manufacturing where a continuous filament of thermoplastic material is fed into a heated extruder and deposited on the current build layer. It is the trademarked name used for systems manufactured by the process inventor, Stratasys. Fused filament fabrication (FFF) is the generic term. Abbreviated as FDM

Fused Filament Fabrication

A type of material extrusion (MEX) additive manufacturing where a continuous filament of thermoplastic material is fed into a heated extruder and deposited on the current build layer. It is the generic name used for systems not manufactured by the process inventor, Stratasys, which uses the term fused deposition modeling. Abbreviated as FFF.

Fused Granulate Fabrication

A type of material extrusion (MEX) additive manufacturing where polymer pellets, the same raw material used in injection molding, are melted, then fed into a heated extruder, and deposited on the current build layer. It varies from most FDM/FFF systems in size of the build volume, the diameter of the nozzle, and use of pellet material instead of filament as feedstock. Also called Big Area Additive Manufacturing (BAAM). Abbreviated as FGF.

Fusing

To combine or blend through melting. In additive manufacturing, fusing is used in several additive manufacturing processes to create parts where material is melted in a pattern or deposited in a pattern to create the build layer.

Fusion

Any process where two or more separate volumes of material are converted into a single volume. Often done with heat and melting the separate volumes or melting the material where they touch. When the material solidifies it creates a single volume.

G-Code

A common computer language used to control the motion of machines, most commonly CNC machining systems. Also used in additive manufacturing to describe the motion of deposition or extruder heads.

Galvo

An electro-mechanical device that converts an electrical signal into a magnetic field that in turn moves a set of mirrors. This allows for very fast and precise pointing of the mirrors. In manufacturing and especially additive manufacturing, a mirror galvanometer is used to point a laser beam onto the build service. This produces the scanning pattern used in vat photopolymerization and powder bed fusion processes that use a laser. Most systems use two mirrors, one for the x-axis and one for the y-axis. Some systems will use multiple laser and mirror galvanometers to scan in parallel. The speed and accuracy of the mirror galvanometer determine the speed and accuracy of the machine that uses them.

Gantry

A physical structure that crosses an area that can be used to move something. A gantry crane is a good example. In additive manufacturing,

the gantry usually refers to the solid, structural part of the frame that a caraie can move linearly along. But it may also refer to a small gantry crane that is used to move heavy parts from one station to another, as in large metal powder bed fusion applications.

Gas Nitriding

A heat treating process used to harden the surface metal parts by heating the part to a high temperature in a chamber filled with a nitrogen-rich gas. When the gas touches the heated part, it causes the gas molecule to break down, and the nitrogen atoms diffuse into the outer surface of the heated part, creating a nitride layer. Gas nitriding can occur in some additive manufacturing processes when the build chamber is filled with nitrogen or a nitrogen-rich gas. Or it can be used as a heat treatment in post-processing to create a hardened surface.

GDP

A variation on material extrusion additive manufacturing where a gel consisting of a photopolymer is extruded from the print head instead of a thermoplastic. The gel is deposited on the current build layer and hardened with an ultraviolet lamp. It can be much faster than thermoplastic material extrusion. Abbreviated as GDP.

Gel Dispensed Printing

A variation on material extrusion additive manufacturing where a gel consisting of a photopolymer is extruded from the print head instead of a thermoplastic. The gel is deposited on the current build layer and hardened with an ultraviolet lamp. It can be much faster than thermoplastic material extrusion. Abbreviated as GDP.

Generative Design

A process where the design of an object or objects is programmatically varied until the behavior of the object best meets the objectives set by the designer. Geometry, topology, material properties, and other attributes of the object are varied. Many methods can be used, including topological optimization, genetic variation, machine learning, goal seeking, or Monte Carlo.

Geometry

The mathematical definition of an object. Usually in a CAD file.

Geometry Kernel

The library used in a CAD package to manage the creation, modification, and storage of geometry. The kernel can be proprietary to the CAD package or a third-party library that is used by many CAD programs. ACIS and Parasolid are the two most common kernels. In additive manufacturing, the kernel is important because geometry can be stored and transferred between programs in the native kernel format, avoiding translations.

Glass Transition Temperature

The temperature above which a given material transitions from hard material to a rubbery material. In polymers, materials below the glass transition temperature are rigid and brittle. Above the temperature they are easily deformed and may freely flow. In additive manufacturing, the glass transition temperature is important because above that temperature, material can be transported and deposited. Then when it cools below that temperature, it hardens and bonds with the previous layer. Most polymer material extrusion system work on this principal.

Granular Materials Binding

A term for both powder bed fusion and binder jetting additive manufacturing processes. Referring to a building process that either fuses or binds a granular material in a powder bed to form a layer.

Graphene

A crystalline form of pure carbon where a single layer of atoms are arranged in a 2D honeycomb structure. In additive manufacturing, graphene can be used as an additive in build material to create a composite material.

Green Part

In sintering, a part that is made of powdered material that has been compressed and held together with a binding material. A green part is delicate. It is heated and/or chemically treated to remove the binding material, producing a brown part.

Grit Blast

A form of abrasive blasting where small angular particles are propelled through a nozzle with compressed air to smooth a rough surface. More aggressive than bead blasting because of the use of hard material with angular shapes.

Hardcoat

A form of anodizing where aluminum oxide is deposited using an electrochemical process in sulphuric acid In additive manufacturing, it is used to create a strong, smooth surface on aluminum parts as a post-processing step. 3D Printed masking may also be used as tooling in the hardcoat process.

Hardening

In metallurgy, a metalworking process where a part is chemically or mechanically treated to increase the yield strength, usually on the surface. In additive manufacturing, it may also refer to the solidification of a part from liquid or highly flexible to rigid.

Heat Affected Zone

In laser powder bed fusion, the volume of material that is adjacent to the area which is melting when the energy beam, usually a laser or electron beam, moves across the top of the build powder. The heating can cause material property changes and will contain thermal stresses.

Heat Deflection

A material property of a thermoplastic that is used to understand the impact of temperature on the flexibility of the material. In additive manufacturing, once a part cools to below the heat deflection temperature it is safe to handle.

Heat Treat

A group of processes used to alter the physical properties of a material. In additive manufacturing, it refers to using heat to relieve residual stresses. It can also be used to increase the strength or hardness of the metal by modifying the microstructure of the material, and there fore changing the macro properties.

Heat Zone

In FDM/FFF, the portion of the head where the filament is heated from room temperature to the printing temperature.

Heated Bed

A build platform that is heated to avoid uneven cooling of parts as they are being built. Usually used in material extrusion systems where the build material requires a relatively high temperature to extrude properly.

High Impact Polystyrene

A thermoplastic material used in lower heat applications that is commonly used in thermoforming. In additive manufacturing, it is used as both a build and support material. As a build material, it holds paint and adhesives well. As a support material that is used with ABS, it dissolves in d-Limonene leaving the build material unharmed. Abbreviated as HIPS.

High Speed Sintering

An additive manufacturing process that is a hybrid of powder bed fusion and binder jetting. Inkjet print heads deposit an infrared absorbing material in the pattern wanted for that layer on the top layer of a powder bed. Then heat from a lamp is used to fuse the material where the absorbing chemical was deposited. It is faster than selective laser sintering and creates stronger parts than binder jetting because the powder is fused and not bonded. Similar to multi jet fusion (MJF) and selective absorption fusion (SAF). Abbreviated as HSS.

HIP

A manufacturing process here metal or ceramic parts are subjected to elevated temperatures in a pressurized tank containing an inert gas. This causes the material in the part to compress, removing voids and increasing the mechanical properties of the material. In additive manufacturing, it is used to compress the voices resulting from powder-based processes and to improve the properties of the final part. Abbreviated as HIP and often referred to as "hiping" and parts can be referred to as "hiped."

HIPS

A thermoplastic material used in lower heat applications that is commonly used in thermoforming. In additive manufacturing, it is used as both a build and support material. As a build material, it holds paint and adhesives well. As a support material that is used with ABS, it dissolves in d-Limonene leaving the build material unharmed. Abbreviated as HIPS.

Hobby 3D Printer

A class of 3D printers designed for home use. Usually fused deposition modeling systems, but may also be vat photopolymerization systems. The systems are low-cost and may require significant assembly by the user. Uses open, inexpensive materials. Not designed for heavy use or precision. Other classes of 3D printers include maker and industrial.

Hot End

A term often used for the heated portion of a nozzle in a material extrusion system.

Hot Isostatic Pressing

A manufacturing process here metal or ceramic parts are subjected to elevated temperatures in a pressurized tank containing an inert gas. This causes the material in the part to compress, removing voids and increasing the mechanical properties of the material. In additive manufacturing, it is used to compress the voices resulting from powder-based processes and to improve the properties of the final part. Abbreviated as HIP and often referred to as "hiping" and parts can be referred to as "hiped."

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Hybrid Manufacturing

The combination of two or more different approaches or processes in a way that provides unique benefits from each. In additive manufacturing, hybrid systems are systems that combine two or more additive manufacturing or traditional manufacturing processes in one system. An example would be a directed energy deposition system combined with 5-axis CNC machining.

Hybrid System

The combination of two or more different approaches or processes in a way that provides unique benefits from each. In additive manufacturing, hybrid systems are systems that combine two or more additive manufacturing or traditional manufacturing processes in one system. An example would be a directed energy deposition system combined with 5-axis CNC machining.

Hydrographics

An ink transfer process used to apply printed images onto a part. The desired graphic is printed on a thin PVA film that is then floated on the top of a vat of water. Then, an activation chemical is applied to the film, which turns the film into a liquid, leaving the ink floating on the top layer of the water. The part is then dipped into the water and the image wraps around the part as it is slowly lowered into the liquid. Also referred to as Water Transfer Printing.

Hydrolysis

The breakdown of a chemical caused by a reaction with water. In additive manufacturing, hydrolysis usually refers to water getting into polymer filament or powder that is hygroscopic and changing the chemical composition of the material, making it unusable. For this reason, many materials are stored in vacuum-sealed backs or with desiccants in their bags. It may also refer to the use of water to dissolve highly hygroscopic materials that are used as support materials.

Hygroscopic

Refers to a material that absorbs moisture from the air. Many materials used in additive manufacturing are hygroscopic. If they absorb enough moisture during storage, they may undergo chemical changes (hydrolysis) or the moisture may turn into steam when the material is heated, forming bubbles. For this reason, many materials are stored in vacuum-sealed backs or with desiccants in their bags.

IGES

A vendor-neutral file format for CAD data known as Initial Graphics Exchange Specification (IGES). Created in 1976, IGES became an ANSI standard in 1980. The standard was last modified in 1996 and has been replaced by the ISO STEP standard in many cases. Almost all CAD tools output IGES. It uses the .igs or .iges file extension.

In Situ Monitoring

An inspection technique where sensors are placed inside an additive manufacturing system's build volume to measure different aspects of the build process while it is taking place. Infrared cameras are usually used to capture precise temperature values across each build layer over time. This provides detailed feedback on the process and part as it is constructed. Some additive manufacturing systems use this information to modify build parameters in real-time, others to detect flaws or problems with the build or

the final part. The data can also be combined over multiple builds to improve processes. Also called in situ inspection and is most common in powder bed fusion systems.

Industrial 3D Printers

A class of 3D printers designed for commercial use. Includes every type of additive manufacturing process. The systems are medium- to high-cost. Uses a wide range of materials, often proprietary and certified for a given system. Designed for heavy use, precision, and robust parts. Used for prototyping, tooling, and making end-use parts. May be used in production. Other classes of 3D printers include hobby and maker.

Inert Gas

A gas that does not chemically react with other substances. Most commonly Nitrogen and Argon. Can be made from an element (noble gasses) or a compound of several elements. Used in additive manufacturing to create an atmosphere in the build chamber or inside a material storage container that is free from oxygen to avoid oxidation, including fire and explosions. Highly reactive powdered materials like titanium and aluminum require Argon.

Infill

A cellular or lattice structure used to fill the volume of a part with something other than solid material. Usually, a 2D repeated pattern extruded in the build direction. An infill reduces material use and weight of parts while keeping strength.

Infill Density

The percent of material, by volume, in an infill region. An 80% fill density would have 20% air and 80% build material. It may also refer to the percent of material by area on a given build area. May also be called Infill Density.

Injection Molding

A form of injection molding where molten polymer is injected into a mold. Once that part cools and the polymer hardens, the part is ejected and trimmed. It is the most common method of manufacturing plastic parts. It is common to use the term injection molding to refer to plastic injection molding. Although metal injection molding is also a type of injection molding. In additive manufacturing, high-strength and high-temperature materials can be used to make molds or inserts for plastic injection molding. Additive manufacturing is often used to make a physical prototype of a part before

molds are made. Production additive manufacturing may be a viable alternative for some plastic injection molded parts. Abbreviated as PIM.

Inkjet

A liquid deposition process that propels (jets) very small droplets of material from a print head onto a surface. Many small jets are arranged on the printhead to deposit larger amounts of material at the same time and can be turned on and off to create a pattern. When multiple heads with different materials in each are used together, colors can be created, or materials can be mixed. In additive manufacturing, inkjet methods are used across processes to deposit material that can be the build material, support material, binder, or some other chemical used in the manufacturing process.

Insert

More correctly called a threaded insert, it is a cylindrical bushing with threads on the inside that can be inserted into a plastic part. It replaces threaded holes in metal parts. In additive manufacturing, holes can be designed into parts, and inserts added after manufacturing to allow parts to be screwed together.

Investment Casting

One of the oldest known traditional manufacturing processes, investment casting starts with a pattern that has the same shape as the desired part. The pattern is coated with ceramic to create a hard shell, and then the pattern is melted or burned away, leaving a hollow mold that the desired material, usually metal of some kind, is poured into. The shell is then destroyed to retrieve the cast part. Traditionally the pattern is made from wax. In additive manufacturing, the pattern is created using almost any of the common processes, as long as the build material can be removed from the shell. The most common are FDM/FFF machines that extrude wax and stereolithography machines that use a photopolymer that can be burned out.

Isotropic

Refers to material properties that are the same in every direction. As opposed to orthotropic, which is different along orthogonal directions, or to anisotropic, which is different in two or more directions.

Jig

A physical part or assembly used in manufacturing to control the motion or location of a part or a tool during a manufacturing process. In additive manufacturing, jigs may be made with additive manufacturing or they may

be used in post-processing to control drilling, machining, and gluing. Different from a fixture in that a fixture only holds a part or parts, it does not guide or control the motion or location of another tool.

Kapton Tape

Thin strips of polyimide film with adhesive on one or two sides. The tape can withstand high loads a wide temperature range. It is commonly used as a substrate in electronics for flexible circuits and as insulation. In additive manufacturing, the tape is used to coat the build plate of lower-cost fused deposition modeling systems. Kapton is the trade name for polyimide film registered to duPont.

Kiln Furniture

Tooling used during the sintering process to support parts as they are heated and undergo sintering. . They may consist of green parts that are sintered themselves or fully dense parts placed in with the green parts. Sometimes referred to as scaffolding or support tooling.

L-PBF

An alternative spelling of the abbreviation LPBF, an abbreviation for laser powder bed fusion.

Laminated Object Manufacturing

A type of sheet lamination additive manufacturing where successive sheets of paper, coated with adhesive, are glued together using a heated roller, and each layer is cut to shape with a laser or knife. Abbreviated as LOM.

Laser

A device that emits light in a concentrated beam and common wavelength and phase. In additive manufacturing, lasers are used to draw a defined path on the build layer to solidify, sinter, melt, or cut the built material. The energy, beam size, and frequency are all critical parameters for the given additive manufacturing process being used.

Laser Cladding

Another term for Directed Energy Deposition. Outside of Additive Manufacturing, it can refer to other laser-based processes used to bond metals.

Laser Cusing

Another name for direct laser melting.

Laser Engineered Net Shaping

A type of direct energy deposition additive manufacturing where a powder is directed into a high-energy laser beam and melted before it is deposited on the build layer. Also called laser powder forming. Abbreviated as LENS.

Laser Powder Bed Fusion

A type of powder bed fusion additive manufacturing where a laser is used to melt material on the top layer of a powder bed. Also called metal powder bed fusion or direct laser melting. Most often used to melt metal powder but is used with plastics as with selective laser sintering. Abbreviated as LPBF or L-PBF

Laser Powder Forming

An alternative term for Laser Engineered Net Shaping. Abbreviated as LPF.

Laser Sintering

Any powder bed fusion additive manufacturing process that uses a laser to center the powder, rather than fully melt it. The term is used to differentiate from powder bed fusion processes that fully melts the powder or that uses a different energy source to sinter the powder. Abbreviated as LS.

Lattice

A structure made of connected beam elements, usually in a uniform pattern. In additive manufacturing, lattice structures are used to reduce weight and provide stiffness and mass that vary spatially.

Layer

A horizontal thickness of material. In additive manufacturing, each layer is constructed completely before the next layer is created. In most processes, the layers sit on the same plane as the build plane.

Layer Count

Same as number of layers.

Layer Height

An alternative term for Layer Thickness.

Layer Thickness

The thickness of material on a given layer within a build. The number of layers in a given build is the Z-height of the part divided by the layer thickness.

LCD Masking

A process where a sheet of clear material containing a liquid crystal display (LCD) is used to block light from a lamp from reaching a surface on the other side of the clear sheet. Pixels in the LCD are turned on and off to project a specific image. In additive manufacturing, LCD masking is used to project a pattern of light onto a build layer. This can be used to solidify a photopolymer in vat photopolymerization with an ultraviolet lamp or to fuse powder in powder bed fusion with an infrared lamp.

LDEPD

A new, novel and still experimental additive manufacturing process that currently does not fit in of the defined process types, but most closely resembles sheet lamination. Electrophoretic Deposition is a process where a then layer of material is placed on an electrode surface. Then a current is used to bond and solidify the material onto the metal electrode and unbonded material is washed away. Electrophoretic deposition has been used in many industries to deposit primers and ceramic layers. In light-directed electrophoretic deposition, a photosensitive electrode is used that only holds a charge if the surface has been exposed to light. In this way, multiple thin layers of material can be deposited and built up using the masking of a light source. Abbreviated as LDEPD

LDM

A form of material extrusion (MEX) additive manufacturing that does not heat the material for extrusion. Chemical reactions or light are used to solidify the deposited layers. Usually used in tissue printing. Abbreviated at LDM.

Lead Screw

A type of linear actuator where a threaded rod is rotated to move a nut along the rod. It is an accurate method of linear actuation that can also move considerable loads. Also referred to as a lead screw. The nut may be threaded or may contain ball bearings that ride in the rod threads, reducing friction. In additive manufacturing, a screw drive is used to linearly move components in the additive machine with precision. A screw drive is more accurate and durable than a belt drive.

LENS

A type of direct energy deposition additive manufacturing where a powder is directed into a high-energy laser beam and melted before it is deposited on the build layer. Also called laser powder forming. Abbreviated as LENS.

Light-Directed Electrophoretic Deposition

A new, novel and still experimental additive manufacturing process that currently does not fit in of the defined process types, but most closely resembles sheet lamination. Electrophoretic Deposition is a process where a then layer of material is placed on an electrode surface. Then a current is used to bond and solidify the material onto the metal electrode and unbonded material is washed away. Electrophoretic deposition has been used in many industries to deposit primers and ceramic layers. In light-directed electrophoretic deposition, a photosensitive electrode is used that only holds a charge if the surface has been exposed to light. In this way, multiple thin layers of material can be deposited and built up using the masking of a light source. Abbreviated as LDEPD

Lightweighting

The process of removing material in a part to reduce the weight of the part. May be accomplished with a lattice structure, infill, or removing unneeded material through topological optimization.

Limit Switch

An electro-mechanical switch used in machines to detect when a moving part has reached a certain position, and then send a stop signal. Also called an endstop.

Limonene

A chemical derived from the oil in citrus fruit. It is used as a dietary supplement, fragrance, food-manufacturing, flavoring, insecticide, herbicide, solvent, and cleaning products. In additive manufacturing, it is used as a solvent to remove high-impact polystyrene (HIPS) when used as a support material. Sometimes referred to as Limonene.

Linear Bearing

A bearing designed to allow smooth, precise motion in only one direction. Also called a linear slide. In additive manufacturing, linear bearings are used to provide precise motion in the x-, y-, or z-axis. They are often used with a belt drive or screw drive.

LOM

A type of sheet lamination additive manufacturing where successive sheets of paper, coated with adhesive, are glued together using a heated roller, and each layer is cut to shape with a laser or knife. Abbreviated as LOM.

Low-Temperature Deposition Modeling

A form of material extrusion (MEX) additive manufacturing that does not heat the material for extrusion. Chemical reactions or light are used to solidify the deposited layers. Usually used in tissue printing. Abbreviated at LDM.

LPBF

A type of powder bed fusion additive manufacturing where a laser is used to melt material on the top layer of a powder bed. Also called metal powder bed fusion or direct laser melting. Most often used to melt metal powder but is used with plastics as with selective laser sintering. Abbreviated as LPBF or L-PBF

LPF

An alternative term for Laser Engineered Net Shaping. Abbreviated as LPF.

LS

Any powder bed fusion additive manufacturing process that uses a laser to center the powder, rather than fully melt it. The term is used to differentiate from powder bed fusion processes that fully melts the powder or that uses a different energy source to sinter the powder. Abbreviated as LS.

Machine Bounding Box

A bounding box with surfaces parallel to the machine coordinate system.

Machine Coordinate System

The Cartesian coordinate system that defines any location inside the build volume. Usually, the z-axis is up from the build plate, the x-axis is from left to right on the build plate, and y-axis is usually away from front towards the back on the build play. The origin varies from system to system.

Machine Home

The reference point in the build volume where additive manufacturing system manufacturer established the machine coordinate system.

Machine Origin

The reference point in the build volume where additive manufacturing system manufacturer established the machine coordinate system.

Machine Zero Point

The reference point in the build volume where additive manufacturing system manufacturer established the machine coordinate system.

Maker 3D Printer

A class of 3D printers designed for use by makers. Usually fused deposition modeling systems, but may also be vat photopolymerization systems. The systems are medium-cost and may require assembly by the user. Uses a wide range of open materials. Designed for moderate use, precision, and robust parts. Used for prototyping and making end-use parts. Other classes of 3D printers include hobby and industrial.

Manufacturing Lot

A set of parts that were created with the same feedstock, build parameters, production run, additive manufacturing system, and post processing.

Master Bounding Box

The bounding box containing all of the parts in a single, multi-part build.

Material Extrusion

Any additive manufacturing process where a viscous material is extruded through a nozzle whose position is computer controlled to lay down a bead of material to create a layer. Fused deposition modeling is the most common form of material extrusion. One of the defined standard categories of ASTM additive manufacturing processes. Abbreviated as MEX.

Material Jetting

Any additive manufacturing process where build or support material is jetted through multiple small nozzles whose position is computer controlled to lay down material to create a layer. One of the defined standard catagories of ASTM additive manufacturing processes. Abbreviated as MJT.

Material Supplier

The company or organization that supplies the material used in an additive manufacturing system

Maximum Layer Thickness

The largest thickness that a given additive manufacturing machine can create.

MCAD

Refers to the digital definition of single physical object or multiple physical objects. It is a more specific form of the term Comptuer Aided Design (CAD) in that it refers to mechanical designs rather than electrical or civil. The abbreviation, MCAD, is used more often than the full term. MCAD software is used to define geometry, topology, and non-geometric attributes for objects.

Mechanical Computer Aided Design

Refers to the digital definition of single physical object or multiple physical objects. It is a more specific form of the term Comptuer Aided Design (CAD) in that it refers to mechanical designs rather than electrical or civil. The abbreviation, MCAD, is used more often than the full term. MCAD software is used to define geometry, topology, and non-geometric attributes for objects.

Media Blasting

A form of abrasive blasting where material particles are propelled through a nozzle with compressed air to smooth a rough surface. Grit blasting, bead blasting, and abrasive blasting are all forms of media blasting.

Melt Pool

In laser powder bed fusion, the volume of material that is melting when the energy beam, usually a laser or electron beam, moves across the top of the build powder. The size of the melt pool determines many characteristics of the material once it solidifies.

Melted and Extruded Modeling

A type of material extrusion additive manufacturing where a material is fed into a heated extruder where it is fully melted and then deposited on the current build layer. It is a more general term than fused filament fabrication because it refers to any feedstock that is fully melted. However, it does not refer to processes where the feedstock is softened for extrusion, but not melted. Abbreviated as MEM.

Melting

A process where a solid material is heated in some way so that its phase changes from solid to liquid. In additive manufacturing, material is often melted to convert a powder into a continuous solid.

Melting Temperature

The temperature at which a given material transitions from solid to liquid.

MEM

A type of material extrusion additive manufacturing where a material is fed into a heated extruder where it is fully melted and then deposited on the current build layer. It is a more general term than fused filament fabrication because it refers to any feedstock that is fully melted. However, it does not refer to processes where the feedstock is softened for extrusion, but not melted. Abbreviated as MEM.

MEMS

Microscopic electro-mechanical machines manufactured using semiconductor manufacturing processes. In additive manufacturing, they are used as actuators in inkjet print heads, mirrors in DLP systems, and as sensors in other devices. Abbreviated as MEMS.

Metal

In manufacturing, a class of materials that are opaque, lustrous or shiny, and are good conductors of electricity and heat. They are usually ductile and can be an element or an alloy.

Metal Injection Molding

A form of injection molding where a fine metal powder, mixed with a binding material, is injected into the mold to create a brown part. That part then goes through debonding to produce a green part. The green part is then sintered. Although not an additive manufacturing process, additive manufacturing can be used to create the tooling used. It is also of interest to those using additive manufacturing processes to create a brown part since the follow-on steps and the design limitations are similar. Abbreviated as MIM.

Metal Powder Bed Fusion

A type of powder bed fusion additive manufacturing where a laser is used to melt material on the top layer of a powder bed. Also called laser powder bed Fusion or direct laser melting. Abbreviated as MPBF.

Metrology

The science and application of measurement. In additive manufacturing, metrology is used to measure the accuracy of parts once they are made. It may be as simple as measuring a key dimension with calipers or as complex as a surface finish measurement using interferometry. Some metrology may take place during a build with in situ monitoring.

MEX

Any additive manufacturing process where a viscous material is extruded through a nozzle whose position is computer controlled to lay down a bead of material to create a layer. Fused deposition modeling is the most common form of material extrusion. One of the defined standard categories of ASTM additive manufacturing processes. Abbreviated as MEX.

Microelectromechanical Systems

Microscopic electro-mechanical machines manufactured using semiconductor manufacturing processes. In additive manufacturing, they are used as actuators in inkjet print heads, mirrors in DLP systems, and as sensors in other devices. Abbreviated as MEMS.

Microstructure

The small-scale structure of a material which can be viewed with an optical microscope. The microstructure strongly influences the physical properties of the material. In additive manufacturing, the microstructure in a part is heavily influenced by how the part is built, the temperature of the part over time during the build, and what post-processing is applied.

MIM

A form of injection molding where a fine metal powder, mixed with a binding material, is injected into the mold to create a brown part. That part then goes through debonding to produce a green part. The green part is then sintered. Although not an additive manufacturing process, additive manufacturing can be used to create the tooling used. It is also of interest to those using additive manufacturing processes to create a brown part since the follow-on steps and the design limitations are similar. Abbreviated as MIM.

Minimum Layer Thickness

The smallest thickness that a given additive manufacturing machine can create. The minimum layer thickness is also the smallest feature size in the Z direction.

Mirror Galvanometer

An electro-mechanical device that converts an electrical signal into a magnetic field that in turn moves a set of mirrors. This allows for very fast and precise pointing of the mirrors. In manufacturing and especially additive manufacturing, a mirror galvanometer is used to point a laser beam onto the build service. This produces the scanning pattern used in vat photopolymerization and powder bed fusion processes that use a laser. Most systems use two mirrors, one for the x-axis and one for the y-axis. Some systems will use multiple laser and mirror galvanometers to scan in parallel. The speed and accuracy of the mirror galvanometer determine the speed and accuracy of the machine that uses them.

MJ

Any additive manufacturing process where build or support material is jetted through multiple small nozzles whose position is computer controlled to lay down material to create a layer. One of the defined standard catagories of ASTM additive manufacturing processes. Abbreviated as MJT.

MJF

An additive manufacturing process that is a hybrid of powder bed fusion and some of the techniques used in binder jetting. Multiple inkjet print heads deposit material that either reflects or absorbs heat on the top layer of a powder bed. Then heat from a lamp is used to fuse the material where the absorbing chemicals were deposited. It is faster than selective laser sintering and creates stronger parts than binder jetting because the powder is fused and not bonded. Similar to as high speed sintering (HSS) and selective absorption fusion (SAF). Abbreviated as MJF.

MJP

A type of material jetting additive manufacturing that jets a photopolymer from multiple inkjet print heads to form a layer of material. A UV lamp is used to cure each layer after it is deposited. MultiJet systems can deposit one material per head, allowing for as many materials to be deposited on a given layer as there are print heads in the machine. The small droplet size also allows materials to be combined to form new materials with

unique stiffness, transparency, or color. Also called PolyJet printing. Abbreviated as MJP.

MJS

A type of material extrusion additive manufacturing where the extruded material consists of metal or ceramic powder with a binder. It is used to create metal or ceramic parts in multiple steps, or phases. After a brown part is built, the binding material is removed with chemicals or heat, and a green part is created that can then be sintered. Abbreviated as MJS.

MJT

Any additive manufacturing process where build or support material is jetted through multiple small nozzles whose position is computer controlled to lay down material to create a layer. One of the defined standard catagories of ASTM additive manufacturing processes. Abbreviated as MJT.

Model Material

The material that the part is built from. Usually referred to as build material. Other materials used may be considered binder or support material.

Mold

A single part, or an assembly of parts, used as a pattern to shape material into a desired shape. When the parts are assembled, they create a cavity of the desired shape of the part. Material can be poured or injected into the cavity as a liquid. Once the material hardens, the part is removed from the cavity.

Molding

One of the traditional manufacturing processes where material is injected under pressure into a cavity that is the shape of the desired part.

Monomer

A molecule that can form bonds with other molecules to form polymers. In additive manufacturing monomers are often joined to form polymers using light, heat, or other chemicals to form a layer of material.

MPBF

A type of powder bed fusion additive manufacturing where a laser is used to melt material on the top layer of a powder bed. Also called laser powder bed Fusion or direct laser melting. Abbreviated as MPBF.

Multi Jet Fusion

An additive manufacturing process that is a hybrid of powder bed fusion and some of the techniques used in binder jetting. Multiple inkjet print heads deposit material that either reflects or absorbs heat on the top layer of a powder bed. Then heat from a lamp is used to fuse the material where the absorbing chemicals were deposited. It is faster than selective laser sintering and creates stronger parts than binder jetting because the powder is fused and not bonded. Similar to as high speed sintering (HSS) and selective absorption fusion (SAF). Abbreviated as MJF.

Multi-step Process

Any type of additive manufacturing where parts are created in more than one step. Most multi-step processes start by creating the basic geometry shape and then additional steps modify the shape, consolidates the material, or changes the material properties.

MultiJet Printing

A type of material jetting additive manufacturing that jets a photopolymer from multiple inkjet print heads to form a layer of material. A UV lamp is used to cure each layer after it is deposited. MultiJet systems can deposit one material per head, allowing for as many materials to be deposited on a given layer as there are print heads in the machine. The small droplet size also allows materials to be combined to form new materials with unique stiffness, transparency, or color. Also called PolyJet printing. Abbreviated as MJP.

Multiphase Jet Solidification

A type of material extrusion additive manufacturing where the extruded material consists of metal or ceramic powder with a binder. It is used to create metal or ceramic parts in multiple steps, or phases. After a brown part is built, the binding material is removed with chemicals or heat, and a green part is created that can then be sintered. Abbreviated as MJS.

Nanomaterials

Materials where a single particle, called a nanoparticle, is in the 1 to 100-nanometer range. In additive manufacturing, nanomaterials are used as an additive in the base material to provide improved physical properties.

Nanoparticle Jetting

A material jetting additive manufacturing process where nanoparticles of the desired final material are suspended in a liquid that is also a bonding agent.

The nanoparticle-containing liquid is deposited with inkjet printheads onto the build layer in a heated bed. The temperature is high enough for the liquid to evaporate most of the liquid upon deposition and also bond the nanoparticles. This process is repeated for each layer. The final part is then washed to remove any remaining bonding liquid, producing a green part that can then be sintered. Abbreviated as NPJ.

Native Format

Refers to a CAD file that stores geometry in a format defined to a specific CAD system. A native file format may be proprietary or published. Opposite of a neutral file. Many CAD tools can now read native files from other vendors, and many additive manufacturing software tools can read the more common native files.

Near Net Shape

Refers to a part that is manufactured to dimensions that are close to or larger than the desired final dimensions. Further post-processing is used to achieve the required dimensions.

Nesting

Packing multiple parts into the build volume of a machine to create the fastest and most efficient build or fitting as many parts as possible in the smallest build volume possible. Parts are often placed inside the cavities of other parts.

Neutral File

Refers to a CAD file that stores geometry in an agreed-upon and documented common format that most software tools that work with CAD geometry can read and write. The two most common neutral file formats are IGES, STEP. STL files are also considered a neutral file.

Nozzle

A device that is used to control the direction and characteristics of a fluid material that passes through the device. In additive manufacturing, nozzles are used to deposit material on a layer, and their position is numerically controlled in the horizontal and vertical directions. additive manufacturing systems may also use a heater to convert material from solid to liquid in the nozzle.

NPJ

A material jetting additive manufacturing process where nanoparticles of the desired final material are suspended in a liquid that is also a bonding agent.

The nanoparticle-containing liquid is deposited with inkjet printheads onto the build layer in a heated bed. The temperature is high enough for the liquid to evaporate most of the liquid upon deposition and also bond the nanoparticles. This process is repeated for each layer. The final part is then washed to remove any remaining bonding liquid, producing a green part that can then be sintered. Abbreviated as NPJ.

Number of Layers

The number of layers in a given build. This value is often used to display the progress of a build, and it can be the dominant factor in determining the build time of a given part. Same as layer count. The number of layers is the Z-height divided by the layer thickness.

NURBS

Abbreviation for non-uniform rational B-spline. A mathematical model used in CAD to represent an arbitrarily shaped 3D curve or surface. NURBS are the most common way in which geometry is defined in CAD. In additive manufacturing, NURB surfaces are usually converted to facets to simplify slicing to calculate tool paths for each build layer.

Nylon

A family of synthetic polymers made from polyamides. Nylons are usually made up of heavy molecules linked in repeating patterns. It is a common material in many additive manufacturing processes.

OBJ

An ASCII text neutral file format for faceted geometry. It was developed for computer rendering and animation and, therefore, contains a faceted definition of the outside surface of an object plus information on how to texture/color each facet. OBJ files use the .obj file extension.

Orientation

The rotational position of an object relative to a specified coordinate system. In additive manufacturing, orientation usually refers to how the part is rotated in the build volume with respect to the build direction. Because additive manufacturing is a layered manufacturing process, the orientation of a part determines how the part is converted into stacked layers of material. It, therefore, has a significant impact on the supports needed, the build time, the strength of the resulting part, and the surface finish.

Orthotropic

Refers to material properties that differ in each orthogonal direction. As opposed to isotropic, which is the same in all directions, or to anisotropic, which is different in two or more directions. Many additive manufacturing parts come out of their process with orthotropic properties with the material stiffness and density in strength in the build direction different than the properties orthogonal to the build direction.

Overcure

A process that uses a photopolymer, when the material cures more than desired. This can cause the resulting material to be more rigid than desired or to not bond to the layers above and below, or to the build plate.

Overflow Region

For powder bed fusion additive manufacturing systems, the region of a system where the excess powder from adding a layer of material is stored during a build.

Overhang

A portion of geometry that has no build material underneath it. Overhangs must be supported with powder or support material. The first layer of an overhang must have something to be built upon.

Overlap

The common area between two parallel paths of material deposition, melting, hardening, binding, sintering, etc., where the material processing is done with some sort of linear process.

P3

A type of vat photopolymerization additive manufacturing where a projector under a transparent build plate shines ultraviolet light onto the build layer, which is against the transparent build plate. The part is then pulled upward so that a new layer of liquid fills between the build plate and the part, and the process is repeated. This process also includes precise control of temperature, pull forces, and fluid flow in the vat. Abbreviated as P3.

PA

A natural or synthetic polymer where the monomers are linked by peptide bonds. Various types of Nylon are a type of polyamide used in additive manufacturing.

Packing

Arranging multiple parts into the build volume of a machine.

PAEK

A family of semi-crystalline thermoplastics with high strength and high-temperature properties. PAEK materials are used across additive manufacturing processes when materials with high strength at high temperatures are required. They also withstand harsh chemicals, resist fire, and are dimensionally stable over time. There are a large variety of polymers in the family, where the number of ether and keytone sequences vary to provide different properties. They
include: Polyetherketone (PEK) Polyetheretherketone (PEEK)Polyetherketonek etone (PEKK)

Parasolid File

A native CAD file format for the Parasolid geometry kernel. It is a published format that many programs can read, even if they do not use the Parasolid geometry kernel.

Part

A single physical object. In additive manufacturing, a part is the object being created.

Part Bed

Another term for Powder Bed

Part Cake

For a powder bed fusion additive manufacturing process, the block that remains after a build that contains powder that is lightly bonded by the high temperature in the build chamber. The built parts are contained within the lightly bonded powder.

Part Consolidation

A design process where an assembly made up of many parts is redesigned to be made with fewer parts by combining multiple parts that would otherwise be bonded, welded, brazed, or fastened together into a single part. This is often done by using additive manufacturing processes to create parts that would need to be made in multiple parts because of the constraints of traditional manufacturing. Welded assemblies are a common type

of assembly that can benefit from part consolidation using additive manufacturing.

Part Location

The position of a given part in the build volume, normally specified as the location part's geometric center in the build coordinate system.

PBF

A class of additive manufacturing process that use a thin beam of energy, usually a laser or electron beam, to draw on the top layer of a bed of powder. The powder is melted as the beam traces over the top layer, and when the energy is moved to a new location, the melted material solidifies and fuses with the solid material underneath or with adjacent fused material on the layer. After a layer is created, the build plate descends by the layer thickness and a new layer of powder is spread over the just created layer. This process is repeated for every layer in the part. One of the defined standard catagories of ASTM additive manufacturing processes. Abbreviated as PBF.

PBT

A thermoplastic polyester that is strong and stiff. In additive manufacturing, it can be combined with polycarbonate to increase its strength or it can be used as an alternative to PET very similar thermoplastic polyester. Abbreviated as PBT.

PC

A group of thermoplastic polymers that are strong, tough, and rigid. Some variations are also transparent. In additive manufacturing, polycarbonates are used heavily in industrial fused deposition modeling systems. It has a relatively high melting temperature when compared to other polymers used in additive manufacturing, and is therefore not well suited for hobby or maker additive manufacturing systems. PC also highly hygroscopic. It is popular for high impact, high heat, and high deflection applications. Abbreviated as PC.

PCL

A biodegradable polyester thermoplastic. It is a biocompatible material approved by the FDA for use in human bodies. In additive manufacturing, it is often used as a scaffolding for bone tissue engineering. Abbreviated as PCL

PEEK

A family of semi-crystalline thermoplastics with high strength and high-temperature properties. PAEK materials are used across additive manufacturing processes when materials with high strength at high temperatures are required. They also withstand harsh chemicals, resist fire, and are dimensionally stable over time. There are a large variety of polymers in the family, where the number of ether and keytone sequences vary to provide different properties. They
include: Polyetherketone (PEK) Polyetheretherketone (PEEK)Polyetherketonek etone (PEKK)

PEI

A family of amorphous thermoplastics that is similar to PEEK. It costs less but has a lower operating temperature range than PEEK. It is easily machined, has good chemical and flame resistance, can survive steam sterilization, is biocompatible, and is approved for food contact. A family of PEI materials is also known under the trade name of ULTEM. Several ULTEM materials used in industrial FDM systems are approved for use in aerospace applications. In additive manufacturing, both PEI is used as a build material for high-strength and high-temperature applications in fused deposition modeling systems. Other polymers adhere well to PEI, so PEI sheets are used in many fused deposition modeling systems as a build
surface. ULTEM powder is also available in powder bed fusion systems. Abbreviated as PEI.

PEK

A family of semi-crystalline thermoplastics with high strength and high-temperature properties. PAEK materials are used across additive manufacturing processes when materials with high strength at high temperatures are required. They also withstand harsh chemicals, resist fire, and are dimensionally stable over time. There are a large variety of polymers in the family, where the number of ether and keytone sequences vary to provide different properties. They
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PEKK

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include: Polyetherketone (PEK) Polyetheretherketone (PEEK)Polyetherketonek etone (PEKK)

Perimeter

A curve defining the outside boundary of a closed geometric area In additive manufacturing, it is the outside line of any closed areas on a given build layer. It is the intersection of the part shell with the build plane.
The perimeter is important in additive manufacturing because the tool path or scan pattern along the perimeter determines part accuracy, strength, and surface finish.

PETG

An amorphous copolymer in the polyester family made by combining PET (Polyethylene terephthalate) and glycol. The addition of glycol reduces the brittleness of PET on its own. It is hard, impact-resistant, chemically resistant, transparent, and ductile. It is also approved for use with foods. In additive manufacturing, it is a popular filament material for fused deposition modeling as a transparent, strong material. Carbon fiber can be added to increase stiffness and strength. It is abbreviated as PETG.

PHA

A family of naturally produced polyester materials. PHAs are produced through the bacterial fermentation of lipids or sugars. The process can produce both thermoplastics and elastomers with a wide range of melting temperatures. PHAs can be biocompatible and are biodegradable. In additive manufacturing, PHA materials can be used as a biodegradable and biocompatible material for fused deposition modeling. It is an alternative to petroleum-based polymers. It can also be mixed with other polymers and additives to give it desired properties.

Photocure

The use of light, usually of a specific frequency range, to cure a photo-responsive material. Many additive manufacturing processes use photocuring as a way to convert a liquid into a solid or to harden a viscous solid. All Vat photopolymerization and most material jetting additive manufacturing processes are based on photocuring.

Photopolymer

A liquid resin that turns into a solid when exposed to ultraviolet light. This process is used in several additive manufacturing processes,

including stereolithography, PolyJet, and binder jetting, where a photopolymer is used as the binder.

Photopolymerization

The process of converting a liquid monomer molecules into long chain polymer networks.

Pillowing

A condition in fused deposition modeling when the top layers of a part show raised humps or even holes. This is caused when the top solid layers are deposited on top of infill and the solid layers do not adhere to the infill beneath. It is caused by soft material (print temperature is too high), too few top layers, or not enough infill.

PIM

A form of injection molding where molten polymer is injected into a mold. Once that part cools and the polymer hardens, the part is ejected and trimmed. It is the most common method of manufacturing plastic parts. It is common to use the term injection molding to refer to plastic injection molding. Although metal injection molding is also a type of injection molding. In additive manufacturing, high-strength and high-temperature materials can be used to make molds or inserts for plastic injection molding. Additive manufacturing is often used to make a physical prototype of a part before molds are made. Production additive manufacturing may be a viable alternative for some plastic injection molded parts. Abbreviated as PIM.

PJP

Another name for fused deposition modeling (FDM) or fused filament fabrication (FFF) Abbreviated as PJP.

PLA

A polyester thermoplastic derived from fermented plant starch. Because of its relatively low glass transition temperature and low cost, it is the most popular material in low-cost material extrusion (MEX) systems. Abbreviated as PLA.

Plastic

A material made of polymers that can be made soft and molded into a desired shape.

Plastic Injection Molding

A form of injection molding where molten polymer is injected into a mold. Once that part cools and the polymer hardens, the part is ejected and trimmed. It is the most common method of manufacturing plastic parts. It is common to use the term injection molding to refer to plastic injection molding. Although metal injection molding is also a type of injection molding. In additive manufacturing, high-strength and high-temperature materials can be used to make molds or inserts for plastic injection molding. Additive manufacturing is often used to make a physical prototype of a part before molds are made. Production additive manufacturing may be a viable alternative for some plastic injection molded parts. Abbreviated as PIM.

Plastic Jet Printing

Another name for fused deposition modeling (FDM) or fused filament fabrication (FFF) Abbreviated as PJP.

PMMA

A transparent thermoplastic engineered polymer. It is also called acrylic or acrylic glass and may go by the brand names of Plexiglas, Acrylite, Lucite, and others. It is strong, impact-resistant, and UV-resistant. In additive manufacturing, PMMA is used as a stock material in material extrusion processes and as a powder in binder jetting and powder bed fusion. Although acrylic materials can not be used as a photopolymer needed in material jetting and vat photopolymerization, several acrylic-like materials have been developed for those processes.

Polyamide

A natural or synthetic polymer where the monomers are linked by peptide bonds. Various types of Nylon are a type of polyamide used in additive manufacturing.

Polyaryletherketone

A family of semi-crystalline thermoplastics with high strength and high-temperature properties. PAEK materials are used across additive manufacturing processes when materials with high strength at high temperatures are required. They also withstand harsh chemicals, resist fire, and are dimensionally stable over time. There are a large variety of polymers in the family, where the number of ether and keytone sequences vary to provide different properties. They include: Polyetherketone (PEK) Polyetheretherketone (PEEK)Polyetherketonek etone (PEKK)

Polybutylene terephthalate

A thermoplastic polyester that is strong and stiff. In additive manufacturing, it can be combined with polycarbonate to increase its strength or it can be used as an alternative to PET very similar thermoplastic polyester. Abbreviated as PBT.

Polycaprolactone

A biodegradable polyester thermoplastic. It is a biocompatible material approved by the FDA for use in human bodies. In additive manufacturing, it is often used as a scaffolding for bone tissue engineering. Abbreviated as PCL

Polycarbonate

A group of thermoplastic polymers that are strong, tough, and rigid. Some variations are also transparent. In additive manufacturing, polycarbonates are used heavily in industrial fused deposition modeling systems. It has a relatively high melting temperature when compared to other polymers used in additive manufacturing, and is therefore not well suited for hobby or maker additive manufacturing systems. PC also highly hygroscopic. It is popular for high impact, high heat, and high deflection applications. Abbreviated as PC.

Polyetheretherketone

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include: Polyetherketone (PEK) Polyetheretherketone (PEEK)Polyetherketonek etone (PEKK)

Polyetherimide

A family of amorphous thermoplastics that is similar to PEEK. It costs less but has a lower operating temperature range than PEEK. It is easily machined, has good chemical and flame resistance, can survive steam sterilization, is biocompatible, and is approved for food contact. A family of PEI materials is also known under the trade name of ULTEM. Several ULTEM materials used in industrial FDM systems are approved for use in aerospace applications. In additive manufacturing, both PEI is used as a build material for high-

strength and high-temperature applications in fused deposition modeling systems. Other polymers adhere well to PEI, so PEI sheets are used in many fused deposition modeling systems as a build surface. ULTEM powder is also available in powder bed fusion systems. Abbreviated as PEI.

Polyetherketone

A family of semi-crystalline thermoplastics with high strength and high-temperature properties. PAEK materials are used across additive manufacturing processes when materials with high strength at high temperatures are required. They also withstand harsh chemicals, resist fire, and are dimensionally stable over time. There are a large variety of polymers in the family, where the number of ether and keytone sequences vary to provide different properties. They include: Polyetherketone (PEK) Polyetheretherketone (PEEK)Polyetherketonek etone (PEKK)

Polyetherketoneketone

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Polyethylene Terephthalateglycol

An amorphous copolymer in the polyester family made by combining PET (Polyethylene terephthalate) and glycol. The addition of glycol reduces the brittleness of PET on its own. It is hard, impact-resistant, chemically resistant, transparent, and ductile. It is also approved for use with foods. In additive manufacturing, it is a popular filament material for fused deposition modeling as a transparent, strong material. Carbon fiber can be added to increase stiffness and strength. It is abbreviated as PETG.

Polyhydroxyalkanoates

A family of naturally produced polyester materials. PHAs are produced through the bacterial fermentation of lipids or sugars. The process can produce both thermoplastics and elastomers with a wide range of melting temperatures. PHAs can be biocompatible and are biodegradable. In additive manufacturing, PHA materials can be used as a biodegradable

and biocompatible material for fused deposition modeling. It is an alternative to petroleum-based polymers. It can also be mixed with other polymers and additives to give it desired properties.

PolyJet

A type of material jetting additive manufacturing that jets a photopolymer from multiple inkjet print heads to form a layer of material. A UV lamp is used to cure each layer after it is deposited. PolyJet systems can deposit one material per head, allowing for as many materials to be deposited on a given layer as there are print heads in the machine. The small droplet size also allows materials to be combined to form new materials with unique stiffness, transparency, or color. Also called MultiJet Printing.

Polylactic Acid

A polyester thermoplastic derived from fermented plant starch. Because of its relatively low glass transition temperature and low cost, it is the most popular material in low-cost material extrusion (MEX) systems. Abbreviated as PLA.

Polymer

A type of material made of long chains of organic molecules, where the chains are made of repeating combinations of atoms. In additive manufacturing, polymer usually refers to plastic materials. Polymers are ideal for additive manufacturing because their molecular structure allows them to be softened with heat to a viscous state that can be extruded, formed by curing liquid polymers with heat or light, or even sintered when in a powdered form. Once fully solidified and/or cured, polymers can be very strong and can be engineered to have a wide range of physical characteristics.

Polymethyl methacrylate

A transparent thermoplastic engineered polymer. It is also called acrylic or acrylic glass and may go by the brand names of Plexiglas, Acrylite, Lucite, and others. It is strong, impact-resistant, and UV-resistant. In additive manufacturing, PMMA is used as a stock material in material extrusion processes and as a powder in binder jetting and powder bed fusion. Although acrylic materials can not be used as a photopolymer needed in material jetting and vat photopolymerization, several acrylic-like materials have been developed for those processes.

Polyphenylene Sulfide

A polymer family created by linking aromatic rings with sulfides. It has very high chemical resistance, it does not react with any solvent at temperatures below 200 C. Its strength, ultraviolet resistance, chemical resistance, and temperature resistance drive its use as a high-performance thermoplastic. In additive manufacturing, it is available as a material for both fused deposition modeling and powder bed fusion. Members of the PPS family used in additive manufacturing include Polyphenylsulfone (PPSF or PPSU). Abbreviated as PPS

Polyphenylsulfone

A polymer family created by linking aromatic rings with sulfides. It has very high chemical resistance, it does not react with any solvent at temperatures below 200 C. Its strength, ultraviolet resistance, chemical resistance, and temperature resistance drive its use as a high-performance thermoplastic. In additive manufacturing, it is available as a material for both fused deposition modeling and powder bed fusion. Members of the PPS family used in additive manufacturing include Polyphenylsulfone (PPSF or PPSU). Abbreviated as PPS

Polypropolene

A thermoplastic semi-crystalline polymer that is the second most widely used plastic material in the world. Mechanical properties vary significantly based on the molecular weight and crystallinity of a given batch of material, as well as from additives. It is resistant to fatigue and is therefore often used in applications where the material sees large strains. It is resistant to physical damage, chemicals, impact, and freezing. In additive manufacturing, the material tends to warp upon cooling, making it a challenge to print in systems without heated chambers. The material is used in material extrusion systems in filament and pellet form and as a powder in powder bed fusion systems. There are several photopolymer materials available for vat photopolymerization that are not polypropylene but have been designed to have properties similar to polypropylene. Abbreviated as PP.

Polytetrafluoroethylene

A synthetic fluoropolymer material. It is often referred to by the brand name Teflon. It has one of the lowest coefficients of friction of any solid material. In additive manufacturing, it is used as a material in machines where low friction is required and can also be used as a build material. Abbreviated as PTFE.

Polyurethane

A family of polymers made of organic molecules joined by carbamate (urethane) links. Polyurethane is widely used and the properties are determined by the manufacturing process and additives. In additive manufacturing, many polyurethane materials are available in filament, powder, and photopolymer forms. It is a popular material because it can be made both soft and rigid, has excellent mechanical properties, and is chemically resistant. Abbreviated as PU or PUR.

Polyvinyl Alcohol

Polyvinyl Alcohol is a synthetic polymer that is soft, biodegradable, and dissolves in water. In additive manufacturing, it is used as a support material because of its ability to be water soluble. Abbreviated as PVA.

Porosity

A measure of the amount of voids in a solid part.

Post-Processing

Operations done on a part after being created in an additive manufacturing machine. They may include removing supports, changing the surface finishes, modifying the color of the part, curing, heat treating, creating features with traditional manufacturing, or a variety of steps to convert the part to the desired final configuration.

Powder Batch

The powder used in a powder bed or binder jetting additive manufacturing system that is loaded at the same time. It may contain virgin or used powder.

Powder Bed

For a powder bed fusion or binder jetting additive manufacturing system, the region of the system where the powder is deposited in the build volume, one layer at a time. Each subsequent layer in the powder bed is fused or bonded to create the build parts.

Powder Bed Fusion

A class of additive manufacturing process that use a thin beam of energy, usually a laser or electron beam, to draw on the top layer of a bed of powder. The powder is melted as the beam traces over the top layer, and when the energy is moved to a new location, the melted material solidifies

and fuses with the solid material underneath or with adjacent fused material on the layer. After a layer is created, the build plate descends by the layer thickness and a new layer of powder is spread over the just created layer. This process is repeated for every layer in the part. One of the defined standard catagories of ASTM additive manufacturing processes. Abbreviated as PBF.

Powder Blend

A collection of powder used in powder bed fusion or binder jetting additive manufacturing systems that came from multiple powder lots or from the addition of used powder to one or more lots of virgin powder.

Powder Coating

A process where a powder is attached to the surface of a part using an electrostatic charge and then cured using ultraviolet light or heat. The coating is usually a polymer and creates a harder finish than paint.

Powder Lot

A volume of powder produced by a given manufacturer in a single manufacturing process cycle. The material produced must be traceable and in a controlled environment.

PP

A thermoplastic semi-crystalline polymer that is the second most widely used plastic material in the world. Mechanical properties vary significantly based on the molecular weight and crystallinity of a given batch of material, as well as from additives. It is resistant to fatigue and is therefore often used in applications where the material sees large strains. It is resistant to physical damage, chemicals, impact, and freezing. In additive manufacturing, the material tends to warp upon cooling, making it a challenge to print in systems without heated chambers. The material is used in material extrusion systems in filament and pellet form and as a powder in powder bed fusion systems. There are several photopolymer materials available for vat photopolymerization that are not polypropylene but have been designed to have properties similar to polypropylene. Abbreviated as PP.

PPS

A polymer family created by linking aromatic rings with sulfides. It has very high chemical resistance, it does not react with any solvent at temperatures below 200 C. Its strength, ultraviolet resistance, chemical resistance, and temperature resistance drive its use as a high-performance thermoplastic. In additive manufacturing, it is available as a material for both fused

deposition modeling and powder bed fusion. Members of the PPS family used in additive manufacturing include Polyphenylsulfone (PPSF or PPSU). Abbreviated as PPS

PPSF

A polymer family created by linking aromatic rings with sulfides. It has very high chemical resistance, it does not react with any solvent at temperatures below 200 C. Its strength, ultraviolet resistance, chemical resistance, and temperature resistance drive its use as a high-performance thermoplastic. In additive manufacturing, it is available as a material for both fused deposition modeling and powder bed fusion. Members of the PPS family used in additive manufacturing include Polyphenylsulfone (PPSF or PPSU). Abbreviated as PPS

PPSU

A polymer family created by linking aromatic rings with sulfides. It has very high chemical resistance, it does not react with any solvent at temperatures below 200 C. Its strength, ultraviolet resistance, chemical resistance, and temperature resistance drive its use as a high-performance thermoplastic. In additive manufacturing, it is available as a material for both fused deposition modeling and powder bed fusion. Members of the PPS family used in additive manufacturing include Polyphenylsulfone (PPSF or PPSU). Abbreviated as PPS

Pre-Processing

Converting the desired part geometries, contained in geometry files, for creation in an additive manufacturing system. The part or parts for a given build must be oriented in the build volume, packed or nested, support structures added (if needed), and compensation applied for expected distortion during the build (if needed). The parts are then sliced, and the tool path, mask, or deposition pattern calculated for each layer. Pre-processing often also includes determining the build parameters to be used. In many cases, it also involves repairing the geometry files to be robust enough for slicing. Many other tasks such as creating special holes for material drainage, splitting parts to fit, and adding special features needed for post-processing are done.

Process Monitoring

Using sensors and machine values to capture measurements while a process is taking place. In additive manufacturing, it is capturing and viewing the characteristics of the system as a build is taking place.

Process Parameters

The system settings and operating values that the user can specify or modify in an additive manufacturing system.

Process Simulation

Using numerical simulation techniques to virtually simulate a given build. The goal of process simulation is to allow a user to predict and avoid failures during a build. It is also used to optimize the build parameters, part orientation, and compensate for distortion caused by the build process. It can also be used to optimize support geometry.

Product Definition

The collection of information that fully defines an object. This includes the geometry as well as geometric tolerancing information. Desired surface finishes, other post-processing steps, and any additional information needed to ensure that the part produced is exactly what is desired.

Production Part

A part created through additive manufacturing that is not a prototype, tooling, or a fixture. Production parts are used for the intended purpose of the part.

Production Run

Refers to the act of or the parts produced by either a single build cycle or a series of build cycles that used identical build parameters and the same feedstock batch.

Programmable PhotoPolymerization

A type of vat photopolymerization additive manufacturing where a projector under a transparent build plate shines ultraviolet light onto the build layer, which is against the transparent build plate. The part is then pulled upward so that a new layer of liquid fills between the build plate and the part, and the process is repeated. This process also includes precise control of temperature, pull forces, and fluid flow in the vat. Abbreviated as P3.

Prototype

In manufacturing, a part or assembly that represents a production part. It is used to test the fit, form, and function of an object before it is manufacturing in production.

Prototype Tooling

Dies, fixtures, and molds used to create prototype parts or as a prototype for the tooling itself. The creation of prototype tooling is ideal for additive manufacturing. Stronger materials and more accurate systems allow for the quick creation of prototype tooling in a fraction of the time of tools made from traditional manufacturing.

PTFE

A synthetic fluoropolymer material. It is often referred to by the brand name Teflon. It has one of the lowest coefficients of friction of any solid material. In additive manufacturing, it is used as a material in machines where low friction is required and can also be used as a build material. Abbreviated as PTFE.

PU

A family of polymers made of organic molecules joined by carbamate (urethane) links. Polyurethane is widely used and the properties are determined by the manufacturing process and additives. In additive manufacturing, many polyurethane materials are available in filament, powder, and photopolymer forms. It is a popular material because it can be made both soft and rigid, has excellent mechanical properties, and is chemically resistant. Abbreviated as PU or PUR.

PUR

A family of polymers made of organic molecules joined by carbamate (urethane) links. Polyurethane is widely used and the properties are determined by the manufacturing process and additives. In additive manufacturing, many polyurethane materials are available in filament, powder, and photopolymer forms. It is a popular material because it can be made both soft and rigid, has excellent mechanical properties, and is chemically resistant. Abbreviated as PU or PUR.

PVA

Polyvinyl Alcohol is a synthetic polymer that is soft, biodegradable, and dissolves in water. In additive manufacturing, it is used as a support material because of its ability to be water soluble. Abbreviated as PVA.

QuickCast

A stereolithography build style trademarked by 3D Systems that is used to create investment casting patterns. It is designed to create a pattern that

can be used for investment casting. It can also be used to create lightweight, strong SLA parts.

Raft

Layers of material, usually in a lattice structure, that are printed under a part as a foundation made of build material that the part will be printed on. Most commonly used in FDM/FFF to improve adhesion and decrease warping. An alternative to using a brim or a skirt.

Rapid Prototyping

A model of a physical part that is created using additive manufacturing. Applied as a synonym for additive manufacturing or 3D printing because the original use of additive manufacturing was to create prototypes quickly and rapid prototyping was the most common term used in the 1990s. Abbreviated as RP.

Rapid Tooling

Manufacturing tooling such as jigs, fixtures, molds, and patterns using an additive manufacturing process. Abbreviated as RT.

Raster Pattern

In LPBF, the path a laser takes, or scan pattern followed, as the beam travels across the top layer of powder. Raster patterns consist of parallel lines drawn back and forth across a build layer. The orientation of the lines can vary in patches or be uniform for an entire layer. In FDM/FFM it refers to the pattern used to sparsely fill the interior of a given layer.

Reactive Material

Material that chemically reacts with oxygen, often generating significant heat. Reactive materials can become dangerously hot, starting fires or exploding. When converted to a powder form, the surface area of reactive materials increases and the rate and heat generated can greatly increase.

Reactive Metals

Metals that are considered reactive materials. Titanium and aluminum, which are common materials in metal additive manufacturing, are reactive metals.

Recoater Blade

A horizontal bar that spreads and smooths liquid polymer in vat photopolymerization or powder for powder bed fusion and binder jet

processes to create a uniform and flat layer before the build material is solidified, sintered, melted, or bonded.

Repeatability

In manufacturing, a measure of the variation between multiple measurements of the same property using the same measurement equipment, process, and environment.

Residual Stress

The stress present in an object in the absence of any external load or force. In additive manufacturing, residual stresses are caused by uneven solidification, thermal gradients, and chemical reactions during the build process. Significant residual stress can cause part distortion and warping.

Resin

A highly viscous or solid organic material that can be converted into a polymer. In additive manufacturing, resins are usually liquids that are converted into a solid polymer through the application of light, heat, and/or other chemicals.

Resolution

The smallest increment of a given value that can be measured or produced by a device. In additive manufacturing, it is the length of the smallest feature size.

Retraction

Pulling something back or into something it came out of. In additive manufacturing, retraction refers to pulling material back up into the extrusion nozzle in material extrusion additive manufacturing processes when the device is not actively extruding material. This is done to keep the material from dripping out of the nozzle while the nozzle is not depositing material.

RP

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RT

Manufacturing tooling such as jigs, fixtures, molds, and patterns using an additive manufacturing process. Abbreviated as RT.

SAF

An additive manufacturing process that is a hybrid of powder bed fusion and some of the techniques used in binder jetting. Multiple inkjet print heads deposit an infrared-sensitive material that absorbs heat, enough heat to fuse the particles on the top layer of a powder bed where the heat absorbing material has been deposited when exposed to an infrared lamp. It is faster than selective laser sintering and creates stronger parts than binder jetting because the powder is fused and not bonded. Similar to high speed sintering (HSS) and multi jet fusion (MJF) Abbreviated as SAF.

Sand Casting

A traditional manufacturing metal molding process utilizes a pattern in the shape of the desired part and sand as the mold. The pattern is placed inside the sand and the sand is packed around the pattern and left to harden. The pattern is then removed and molten metal is poured into the cavity to produce the part. In additive manufacturing, the pattern can be produced with multiple additive manufacturing processes.

Scaffolding

A framework used to provide support. In additive manufacturing, scaffolding refers to build material deposited to hold up and support some other material. It may refer to a support structure created to support a sintered part during sintering (also called kiln furniture) or to support material during a build. In bio-printing, a scaffold is built as a substrate on which to grow tissue. Scaffolding may be built from the build material or support material.

Scan Pattern

The path a laser or electron beam traces.

Scan, Spin, and Selective Photocure

A vat photopolymerization process that uses a moving laser assembly. The process moves the laser in the Y-direction while scanning very quickly in the X-direction, solidifying each layer of photopolymer with the laser's ultraviolet beam. It is very similar to stereolithography, which uses a stationary laser assembly in both the X-direction and Y-direction. Abbreviated as 3SP.

Screw Drive

A type of linear actuator where a threaded rod is rotated to move a nut along the rod. It is an accurate method of linear actuation that can also move considerable loads. Also referred to as a lead screw. The nut may be threaded or may contain ball bearings that ride in the rod threads, reducing friction. In additive manufacturing, a screw drive is used to linearly move components in the additive machine with precision. A screw drive is more accurate and durable than a belt drive.

SDL

Another term for sheet lamination. Abbreviated as SDL.

Seam

A visible line in the build direction that appears on a part, usually in FDM/FFF, where the start and stop of the outside surface trace is the same for every layer.

Selective Absorption Fusion

An additive manufacturing process that is a hybrid of powder bed fusion and some of the techniques used in binder jetting. Multiple inkjet print heads deposit an infrared-sensitive material that absorbs heat, enough heat to fuse the particles on the top layer of a powder bed where the heat absorbing material has been deposited when exposed to an infrared lamp. It is faster than selective laser sintering and creates stronger parts than binder jetting because the powder is fused and not bonded. Similar to high speed sintering (HSS) and multi jet fusion (MJF) Abbreviated as SAF.

Selective Deposition Lamination

Another term for sheet lamination. Abbreviated as SDL.

Selective Heat Sintering

A powder bed fusion additive manufacturing process where the powder on the top layer of the powder bed is sintered using a thermal print head instead of a laser. It is otherwise very similar to selective laser sintering (SLS) The build plate is lowered and a new layer of powder is spread and the process is repeated. Abbreviated as SHS.

Selective Laser Melting

Another term for Direct Laser Melting. Abbreviated as SLM.

Selective Laser Reaction Sintering

A powder bed fusion additive manufacturing process where a base powder material and a gas are heated with the scanning laser to cause a chemical reaction that creates the fused ceramic material directly, rather than fusing an existing ceramic powder. Once a layer is completed, the build plate lowers and a new layer of powder is deposited on top, and the process repeats. Abbreviated as SLRS.

Selective Laser Sintering

A type of powder bed fusion additive manufacturing that uses a laser to fuse a polymer powder into a solid one layer at a time. The laser fuses the top layer of the powder in the powder bed, the build plate is lowered, and a new layer of powder is spread across the top of the powder bed. The process is then repeated. The laser used is powerful enough to cause the polymer particles to sinter, but they do not melt and solidify. Abbreviated as SLS.

Selective Thermoplastic Electrophotographic Process

A powder bed fusion additive manufacturing process that utilizes the 2D Electrophotographic process found in laser printers and copy machines. Each layer of powder is created on a series of drums. Each drum picks up a pattern of powder for each material being used and can be a mixture of build and support materials. The process works just as a color 2D printer builds an image from colored toner powder. That build layer is transferred from drum to drum, adding powder as it goes. The full layer is then transferred to a belt and which deposits the build layer powder on top of the previous layer. The layer is heated, and compressed, fused, then cooled. This results in a fully dense part with isotropic properties. Abbreviated as STEP.

Self-Assembly

A process where a disorganized system of components are organized into a structure with no outside direction. In additive manufacturing, self-assembly can refer to chemical processes where a material changes from a random to a structured state. It can also refer to components made with the additive manufacturing process that then assemble themselves into a new, more ordered shape.

Service Provider

In additive manufacturing, a company that manufactures parts for other people using additive manufacturing systems. u. Service providers charge per part and usually offer a variety of different additive

manufacturing technologies and post-processing options. Formerly referred to as a service bureau.

SFF

The creation of solid parts directly from a computer model without the need for any molds or forms. Additive manufacturing is a subset of solid freeform fabrication where the material is added and no substantive processes are used. Sometimes referred to as only Freeform Fabrication.

SGC

A vat photopolymerization additive manufacturing process that cures the photopolymer layer with UV light that has been shaped with a digital mask rather than with a laser or a projector. The process includes multiple steps for each layer, beginning with the solidification of the layer with UV light. After that, excess liquid is removed with blown air, melted wax is spread over the layer to fill voids, then a milling head is used to flatten the surface. Abbreviated as SGC.

Sheet Lamination

A class of additive manufacturing processes where thin, solid sheets of material are stacked and cut one layer at a time. The layers may be bonded through heat, chemical reaction, or adhesives. One of the defined standard catagories of ASTM additive manufacturing processes. Abbreviated as SHL.

Shell

The outer surface of a solid object.

Shell Thickness

A measure of how thick any thin material is, especially the outer shell of a part. In additive manufacturing, it can also refer to the thickness of the outer service of a part that uses infill for its interior. Possible shell thickness is determined by the minimum dimension the additive manufacturing process can build. Shell thickness that is too thick or too thin can cause problems during or after a build because of distortion or failure.

SHL

A class of additive manufacturing processes where thin, solid sheets of material are stacked and cut one layer at a time. The layers may be bonded through heat, chemical reaction, or adhesives. One of the defined standard catagories of ASTM additive manufacturing processes. Abbreviated as SHL.

Shot Peening

A process where small round particles, usually metallic, ceramic, or glass, are impacted against the surface of a metallic part at high enough velocity to cause plastic deformation on the surface. This results in compressive residual stress, strengthening the surface. As with media blasting, compressed air is used to deliver the particles. However, instead of removing material to modify the surface finish, shot peening is used to strengthen the surface.

Shrinkage Compensation

Modifying the shape of an object to be printed so that when the part completes the additive manufacturing process, the dimensions are the desired values. Shrinkage compensation removes the impact of thermal or chemical distortion created by the manufacturing process.

SHS

A powder bed fusion additive manufacturing process where the powder on the top layer of the powder bed is sintered using a thermal print head instead of a laser. It is otherwise very similar to selective laser sintering (SLS) The build plate is lowered and a new layer of powder is spread and the process is repeated. Abbreviated as SHS.

Single-step Process

Any type of additive manufacturing where the part is created in one processes, resulting in the desired geometry and material properties. Support removal or traditional machining additional features are not considered additional steps.

Sinter

A manufacturing process where particles of a given material are fused together when the atoms on the boundaries between particles diffuse into each other where they are touching. Heat, and sometimes pressure, are used to further fuse and compact that material. In additive manufacturing, sintering can be the process used to produce a part or as a post-processing step that creates a denser part that bonded with a material on the surface of the particles.

Sintered

A manufacturing process where particles of a given material are fused together when the atoms on the boundaries between particles diffuse into each other where they are touching. Heat, and sometimes pressure, are used to further fuse and compact that material. In additive

manufacturing, sintering can be the process used to produce a part or as a post-processing step that creates a denser part that bonded with a material on the surface of the particles.

Sintering

A manufacturing process where particles of a given material are fused together when the atoms on the boundaries between particles diffuse into each other where they are touching. Heat, and sometimes pressure, are used to further fuse and compact that material. In additive manufacturing, sintering can be the process used to produce a part or as a post-processing step that creates a denser part that bonded with a material on the surface of the particles.

Skirt

In fused deposition modeling, a single layer of material deposited on the build surface, that outlines but does not touch your part material. It is deposited on the first layer to prime the extruder and establishes a smooth flow of material. It also provides visible material to inspect to make sure the machine is performing correctly. An alternative to using a brim or raft..

SLA

A type of vat photopolymerization additive manufacturing where a laser is used to draw a path on the top layer of the vat, converting the liquid polymer into a solid. The build plate is then lowered, a new layer of liquid covers the top, and the process is repeated. Stereolithography was the first commercially available additive manufacturing process. It is abbreviated as SLA.

Slice

A planer cut through a part. A slice defines the boundaries of the material in a build layer. Pre-processing software creates the slices from the solid model, calculates the boundary for the slice, and then how the layer will be created.

Slicer

The portion of the pre-processing software that slices a solid model into layers to be created.

SLM

Another term for Direct Laser Melting. Abbreviated as SLM.

SLRS

A powder bed fusion additive manufacturing process where a base powder material and a gas are heated with the scanning laser to cause a chemical reaction that creates the fused ceramic material directly, rather than fusing an existing ceramic powder. Once a layer is completed, the build plate lowers and a new layer of powder is deposited on top, and the process repeats. Abbreviated as SLRS.

SLS

A type of powder bed fusion additive manufacturing that uses a laser to fuse a polymer powder into a solid one layer at a time. The laser fuses the top layer of the powder in the powder bed, the build plate is lowered, and a new layer of powder is spread across the top of the powder bed. The process is then repeated. The laser used is powerful enough to cause the polymer particles to sinter, but they do not melt and solidify. Abbreviated as SLS.

Solid Freeform Fabrication

The creation of solid parts directly from a computer model without the need for any molds or forms. Additive manufacturing is a subset of solid freeform fabrication where the material is added and no substantive processes are used. Sometimes referred to as only Freeform Fabrication.

Solid Geometry

The CAD definition of a part that describes a solid object. Because additive manufacturing processes create solid parts, the geometry provided to the pre-processing software must be a valid solid.

Solid Ground Curing

A vat photopolymerization additive manufacturing process that cures the photopolymer layer with UV light that has been shaped with a digital mask rather than with a laser or a projector. The process includes multiple steps for each layer, beginning with the solidification of the layer with UV light. After that, excess liquid is removed with blown air, melted wax is spread over the layer to fill voids, then a milling head is used to flatten the surface. Abbreviated as SGC.

Solid Model

A CAD definition of part geometry that completely defines the geometry, accurately connecting surfaces to create a volume with a clearly defined inside volume and clearly differentiates different parts. A key characteristic

for additive manufacturing of a solid model is that slicing software can easily determine the inside area of the part when it is cut with a plane.

Soluble Support Material

A type of support material that can be dissolved with a liquid that does not damage the build material, avoiding the manual removal of supports.

Spool

A cylindrical object around which film, thread, or filament can be wound. In additive manufacturing, a spool is used for FDM/FFF to store filament and then dispense it into the system.

Stair Steps

A surface feature created by the representation of a curved surface with layers. The offset between where the slice plane intersects the surface on two adjacent layers determines the outside surface of each layer. The difference creates a staircase like feature on the surface.

STEP

A powder bed fusion additive manufacturing process that utilizes the 2D Electrophotographic process found in laser printers and copy machines. Each layer of powder is created on a series of drums. Each drum picks up a pattern of powder for each material being used and can be a mixture of build and support materials. The process works just as a color 2D printer builds an image from colored toner powder. That build layer is transferred from drum to drum, adding powder as it goes. The full layer is then transferred to a belt and which deposits the build layer powder on top of the previous layer. The layer is heated, and compressed, fused, then cooled. This results in a fully dense part with isotropic properties. Abbreviated as STEP.

STEP File

An ISO defined neutral CAD file format. It supports a broader range of object types than the IGES file format and in most cases provides a more robust translation than IGES can. It uses the .stp or .step file format. STEP refers to the ISO 10303 standard which is titled STandard for the Exchange of Product model data.

STEP Process

Abbreviation for Selective Thermoplastic Electrophotographic Process.

Stepper Motor

A type of electric motor that rotates in discrete steps rather than in a continuous motion. This enables precise rotation of a shaft attached to the motor. In additive manufacturing, stepper motors are used to precisely control the motion of components in the system, often by converting rotational motion into linear motion by attaching the stepper motor to a screw drive or a belt drive.

Stereolithography

A type of vat photopolymerization additive manufacturing where a laser is used to draw a path on the top layer of the vat, converting the liquid polymer into a solid. The build plate is then lowered, a new layer of liquid covers the top, and the process is repeated. Stereolithography was the first commercially available additive manufacturing process. It is abbreviated as SLA.

STL File

A file format used in most additive manufacturing processes. It is a faceted representation of the geometry that is easy to slice. The format was developed for stereolithography but is used across technologies. The format is either ASCII or Binary and contains a list of triangles that define the outside surface of an object. For the ASCII Format, Each object is defined as: solid name ... facet... endsolid name For each triangle, the following information is included: facet normal x y z outer loop vertex x y z vertex x y z vertex x y z endloop endfacet Where "x y z" are real numbers separated by space or tabs, defining the normal vector or location of each vertex. This information is encoded as 32-bit floating-point numbers with a header for binary. By default, the format does not contain additional information, like color or curvature, but some vendors have added header information to include additional details about the objects. The format is being deprecated and replaced by 3MF.

Stress Relief

A process where a metallic part is heated to a temperature that makes the material soft enough for any internal stresses to dissipate. In additive manufacturing, it is used to remove internal stresses created from the thermal gradients created during the build process.

Stringing

The deposition of small strands of plastic in a fused deposition modeling system that are not part of the part. It is usually caused by material coming out of the nozzle when it shouldn't.

Subtractive Manufacturing

The classification of traditional manufacturing processes that involve removing material in a controlled way from raw stock to produce a final shape and size. Machining is the most common application.

Support Material

Material used in an additive manufacturing process that is different from the build material and is used to create supports. Support Material is usually a soluble support material or a breakaway support material.

Support Volume

The volume of support material in a build.

Supports

Geometry added to an additive manufacturing build to support overhangs and constrain thermal distortion. Supports may be created from the build material or a different soluble support material or breakaway support material. The geometry and removal of supports is a significant challenge in additive manufacturing.

Surface Angle

The angle of a surface on a part relative to the build plane.

Surface Finish

A measure of the roughness of the surface of a part.

Surface Model

A CAD definition of part geometry that defines only the surface geometry. The surfaces may not be exactly aligned and there is no way to mathematically determine if a point is inside or outside of the part.

System Set-up

The process of setting up an additive manufacturing system for a build.

Tank

A receptacle that holds liquid. In additive manufacturing, tank may refer to the vat in vat photopolymerization, a receptacle in a post-processing system that contains liquid that acts on the part (support removal, cleaning, dyeing), or a storage receptacle for liquid material.

Teflon

Common or brand name for PTFE.

Text File

A human-readable computer file. Also called an ASCII file.

Thermal Stress

Stress in a part caused by differences in temperature or differences in coefficients of thermal expansion. Many additive manufacturing processes create thermal stress.

Thermistor

An electrical resistor whose resistivity is sensitive to temperature. This allows for accurate measurement of temperature by measuring the resistance across the thermistor. Thermistors are more accurate at lower temperatures, -50 C to 250 C. Thermocouples are more common at higher temperatures. In additive manufacturing, thermistors are used for lower temperature applications where they are still accurate but cost less than thermocouples. Most hobby and maker fused deposition modeling systems use a thermistor to measure and control the nozzle temperature.

Thermoplastic

A subset of polymers that become viscous or liquid when heated and harden when cooled. The process of liquefication and solidification is repeatable.

Thermoplastic Elastomer

A copolymer material with both thermoplastic and elastomeric properties, combining the benefits of both types of material. In additive manufacturing, TPE is a popular material type because, as a thermoplastic, it can be melted and then solidified but as an elastomer, it can be used to build parts with rubber-like properties. TPE material can be used in material extrusion and powder bed fusion systems. TPE is generally less rigid than the other thermoplastic elastomer used in additive manufacturing, TPU. It has a

wider range of hardness than TPU. TPE is also less dense and has a rougher finish than TPU. Abbreviated as TPE.

Thermoplastic Polyurethane

A polyurethane material that exhibit both thermoplastic and elastomeric properties, combining the benefits of both types of material. They are made from hard and soft segments of molecules. In additive manufacturing, TPU is a popular material type because, as a thermoplastic, it can be melted and then solidified but as an elastomer, it can be used to build parts with rubber-like properties. TPE material can be used in material extrusion and powder bed fusion systems. TPU is generally more rigid than the other thermoplastic elastomer used in additive manufacturing, TPE. It has a narrower range of hardness than TPE. TPU is also denser and has a smoother finish than TPE.

Thermoset Plastic

A polymer material that irreversibly hardens through curing. Many additive manufacturing processes utilize thermoset plastics to convert a soft or liquid material into a rigid solid.

Tip Diameter

The diameter of the extrusion head in an FDM/FFF system. The tip diameter determines the width of the bead that the head deposits on a layer, as well as how quickly a given layer can be built.

Tool Path

The computer-controlled movement of a tool in a manufacturing process. In additive manufacturing, it is the path of the laser beam, extruder head, or cutting tool.

Tooling

Parts that are used in manufacturing processes to hold, support, or mold the parts being made.

Top Curing System

A subset of vat photopolymerization where the ultraviolet curing light is projected or traced on the top of a vat. Each layer is created, and the build plate descends into the vat, a new layer of liquid covers the top, and a new layer is solidified. Stereolithography is the most common type of top curing system.

Topological Optimization

A shape optimization process that modifies the topology of a part to achieve a goal given a set of loads. Topological optimization often creates geometries that can only be created with additive manufacturing. Sometimes called topology optimization.

Topology

The shape of an object. Specifically, how the various surfaces of an object are connected and arranged regardless of the size of a given surface.

Topology Optimization

A shape optimization process that modifies the topology of a part to achieve a goal given a set of loads. Topological optimization often creates geometries that can only be created with additive manufacturing. Sometimes called topology optimization.

TPE

A copolymer material with both thermoplastic and elastomeric properties, combining the benefits of both types of material. In additive manufacturing, TPE is a popular material type because, as a thermoplastic, it can be melted and then solidified but as an elastomer, it can be used to build parts with rubber-like properties. TPE material can be used in material extrusion and powder bed fusion systems. TPE is generally less rigid than the other thermoplastic elastomer used in additive manufacturing, TPU. It has a wider range of hardness than TPU. TPE is also less dense and has a rougher finish than TPU. Abbreviated as TPE.

TPU

A polyurethane material that exhibit both thermoplastic and elastomeric properties, combining the benefits of both types of material. They are made from hard and soft segments of molecules. In additive manufacturing, TPU is a popular material type because, as a thermoplastic, it can be melted and then solidified but as an elastomer, it can be used to build parts with rubber-like properties. TPE material can be used in material extrusion and powder bed fusion systems. TPU is generally more rigid than the other thermoplastic elastomer used in additive manufacturing, TPE. It has a narrower range of hardness than TPE. TPU is also denser and has a smoother finish than TPE.

Traditional Manufacturing

A term used to refer to manufacturing processes used before the widespread introduction of additive manufacturing. The full spectrum of subtractive and casting processes are considered traditional manufacturing.

Travel

When a print head moves while not extruding or depositing material.

Travel Speed

The speed at which the printing carriage travels when it is not depositing material. Slow travel speeds can result in long build times and in stringing in fused deposition modeling. Fast travel speeds may negatively impact accuracy.

Triangulation

Breaking a surface in a CAD model up into triangles. A form of tesselation where only triangle facets are created. In additive manufacturing, faceted geometry is often used to calculate tool paths for builds, so triangulation is an important step in pre-processing the geometry.

Tribecular

A porous structure of material that is used in medical implants to encourage tissue and bone growth. In additive manufacturing, it is created on electron beam powder bed fusion systems.

Tumbling

A method used to smooth the surface of a manufactured part. The part or parts are placed in a barrel that is filled with various abrasive materials and then rotated. In additive manufacturing, it is a common post-processing method for smoothing the surface of parts and removing stair stepping.

UAM

A type of sheet lamination additive manufacturing that uses ultrasonic energy to weld thin layers of metal together. A mill is then used to cut the shape of each layer. It is unique because each layer can be made of a different metal material. Also called Ultrasonic Consolidation. Abbreviated as UAM.

UC

Another term for Ultrasonic Additive Manufacturing. Abbreviated as UC

ULTEM

A family of amorphous thermoplastics that is similar to PEEK. It costs less but has a lower operating temperature range than PEEK. It is easily machined, has good chemical and flame resistance, can survive steam sterilization, is biocompatible, and is approved for food contact. A family of PEI materials is also known under the trade name of ULTEM. Several ULTEM materials used in industrial FDM systems are approved for use in aerospace applications. In additive manufacturing, both PEI is used as a build material for high-strength and high-temperature applications in fused deposition modeling systems. Other polymers adhere well to PEI, so PEI sheets are used in many fused deposition modeling systems as a build surface. ULTEM powder is also available in powder bed fusion systems. Abbreviated as PEI.

Ultrasonic Additive Manufacturing

A type of sheet lamination additive manufacturing that uses ultrasonic energy to weld thin layers of metal together. A mill is then used to cut the shape of each layer. It is unique because each layer can be made of a different metal material. Also called Ultrasonic Consolidation. Abbreviated as UAM.

Ultrasonic Consolidation

Another term for Ultrasonic Additive Manufacturing. Abbreviated as UC

Ultraviolet Light

Electromagnetic radiation that is at a higher frequency than visible light. Its wavelength is absorbed by organic molecules and change the chemical properties of polymers. This is leveraged in additive manufacturing to turn liquid resins into solid polymers through exposure to ultraviolet light. Also referred to as UV light.

Used Powder

Powder material that has been used at least one time in a powder bed fusion or material jetting additive manufacturing system, but was not fused or bonded. The powder can be recovered from the machine and used as part of a Powder Blend in future builds, or must be disposed of properly.

UV Light

Abbreviation for ultraviolet light.

Valid Solid Model

A CAD part definition that has no errors. Most additive manufacturing pre-processing tools require a valid solid model.

VAM

A vat photopolymerization additive manufacturing process where highly control light from multiple sources is projected into a volume of photopolymer rather than onto the build layer. Strickly speaking, it is not a layer based process. The light from each projector combines at the wavelength level with constructive interference to deliver enough energy to the right voxel to activate the photopolymer. It is also called reverse photo topography. Instead of building up the part layer by layer, the part is solidified inside a sealed, rotating cylinder. AT every rotation, more energy is constructed in the voxels to be solidified. Because of this approach, it can be over an order of magnitude faster than other vat photopolymerization processes. Abbreviated as VAM.

Vapor Smoothing

A post-processing method where the outer surface of a polymer part is dissolved with vaporized acetone, removing stair steps and creating a smooth, glossy surface.

Vat

A large container that holds liquids. In additive manufacturing a vat refers to a container for resin that is to be cured.

Vat Photopolymerization

A class of additive manufacturing processes that utilizes the hardening of a photopolymer with ultraviolet light. A vat of liquid is filled with liquid photopolymer resin, and an ultraviolet light is either traced on the build surface or projected on it. Stereolithography is the most common form of vat photopolymerization. The build layer can be on the top of the vat of liquid or the bottom. One of the defined standard catagories of ASTM additive manufacturing processes. Abbreviated as VPP.

Virgin

Something that is untouched or unused. In additive manufacturing, virgin refers to material, usually powder, that has never been used in a build.

Virgin Powder

Powder material used for in a powder bed fusion or material jetting additive manufacturing system that has not been used in any way in any process.

Viscosity

A property of a liquid material that measure the resistance to flow, caused by the magnitude of internal friction. In additive manufacturing the viscosity of a material impacts how a liquid or powder material is dispensed or how quickly it spreads when it is deposited.

Volumetric 3D Printing

A vat photopolymerization additive manufacturing process where highly control light from multiple sources is projected into a volume of photopolymer rather than onto the build layer. Strickly speaking, it is not a layer based process. The light from each projector combines at the wavelength level with constructive interference to deliver enough energy to the right voxel to activate the photopolymer. It is also called reverse photo topography. Instead of building up the part layer by layer, the part is solidified inside a sealed, rotating cylinder. AT every rotation, more energy is constructed in the voxels to be solidified. Because of this approach, it can be over an order of magnitude faster than other vat photopolymerization processes. Abbreviated as VAM.

Volumetric Additive Manufacturing

A vat photopolymerization additive manufacturing process where highly control light from multiple sources is projected into a volume of photopolymer rather than onto the build layer. Strickly speaking, it is not a layer based process. The light from each projector combines at the wavelength level with constructive interference to deliver enough energy to the right voxel to activate the photopolymer. It is also called reverse photo topography. Instead of building up the part layer by layer, the part is solidified inside a sealed, rotating cylinder. AT every rotation, more energy is constructed in the voxels to be solidified. Because of this approach, it can be over an order of magnitude faster than other vat photopolymerization processes. Abbreviated as VAM.

Voxel

A cubic volume with an assigned value or values in a regular three-dimensional Cartesian grid. Analogous to a pixel in 2D images, voxels are used in 3D space to define properties like color, density, and material fractions. In additive manufacturing, voxels are used to define properties inside an object.

VPP

A class of additive manufacturing processes that utilizes the hardening of a photopolymer with ultraviolet light. A vat of liquid is filled with liquid photopolymer resin, and an ultraviolet light is either traced on the build surface or projected on it. Stereolithography is the most common form of vat photopolymerization. The build layer can be on the top of the vat of liquid or the bottom. One of the defined standard catagories of ASTM additive manufacturing processes. Abbreviated as VPP.

Wall Thickness

The thickness of a thin area of material on a part. In additive manufacturing wall thickness is a key-value because most processes have a minimum thickness they can make. Minimum wall thickness is a design parameter that should be observed when designing parts for additive manufacturing.

Warm Up Time

The length of time that it takes for an additive manufacturing machine to reach its recommended operating temperature. This could be the temperature of the build plate, the air in the chamber, the powder bed, or various components.

Warping

Deformation in a part that occurs during or after manufacturing. Usually caused by thermal or residual stresses.

Water Transfer Printing

An ink transfer process used to apply printed images onto a part. The desired graphic is printed on a thin PVA film that is then floated on the top of a vat of water. Then, an activation chemical is applied to the film, which turns the film into a liquid, leaving the ink floating on the top layer of the water. The part is then dipped into the water and the image wraps around the part as it is slowly lowered into the liquid. Also referred to as Water Transfer Printing.

Watertight Solid

A solid model where there are no gaps in the surface. If the part was real and filled with water, nothing would leak out. Additive manufacturing pre-processing software requires watertight solids in order to create an accurate boundary for each layer and to know which side of a surface is inside of the part and which is on the outside.

Wire Arc Additive Manufacturing

A type of material extrusion additive manufacturing where an electrical arc is used to melt the end of a wire. The liquid material is then deposited on the layer being built as the print head is moved in the X-Y direction.

Wire EDM

A form of electrical dynamic machining (EDM) where a part is cut with a metal wire that serves as the consumable electrode. Current traveling between the electrode and the part creates a spark that erodes material from both the electrode and the part, cutting the part. The wire moves along its length so that it does not erode enough to break.

X-Axis

One of three coordinate directions in a cartesian coordinate system, the first listed. In additive manufacturing, the x-axis is aligned from left to right, parallel with the front of the machine.

X-Y Plane

An imaginary plane that is perpendicular to the build direction. Also referred to as the build plane. The build layers are parallel to the X-Y plane.

Y-Axis

One of three coordinate directions in a cartesian coordinate system, the second listed. In additive manufacturing, the y-axis is aligned from front to back perpendicular to the front of the machine.

Z-Axis

One of three coordinate directions in a cartesian coordinate system, the third listed. In additive manufacturing, the z-axis is aligned from bottom to top, perpendicular to the build plate.

Z-Direction

The direction perpendicular to the layers being created in an additive manufacturing process. It starts at the first layer and points in the direction that material is being added.

Z-Height

The maximum dimension of a part in the build direction. The Z-height determines the number of layers needed to make a part and has a strong influence on build time.

Zero Point

The original of the machine coordinate system.

Zipped File

Shorthand for a file that has been compressed to create a smaller file size. A standard format referred to as ZIP is used. The software to compress and un-compress ZIP files is included in most operating systems. Many service providers ask customers to provide them with zipped versions of their STL files to reduce upload time.