

Chapter 5 - Equipment & Post Processing Techniques

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Design and Process Parameters in 3D printing

Design and process parameters are important considerations in 3D printing, as they can significantly impact the quality and performance of the final printed part. Here are some of the key parameters to consider:

Design parameters:

- Geometric design: The complexity and geometry of the part can affect its printability and may require the use of support structures.
- Orientation: The orientation of the part on the build platform can affect its strength, surface finish, and printing time.
- Wall thickness: The thickness of the walls of the part should be optimized for the specific material being used.
- Infill density: The amount of infill (the internal structure of the part) can affect the strength and weight of the part.

Process parameters:

- Layer height: The thickness of each printed layer can affect the resolution and surface finish of the part.
- Print speed: The speed at which the printer head moves can affect the quality and accuracy of the printed part.
- Extrusion temperature: The temperature at which the material is melted and extruded can affect the strength and quality of the part.
- Bed temperature: The temperature of the build platform can affect the adhesion of the printed part to the platform.
- Cooling rate: The rate at which the printed part cools after each layer can affect its overall quality and strength.

- Support material: The type and density of the support material can affect the quality and ease of removal of the supports from the final part.

Define bonding Mechanism in additive manufacturing

Bonding mechanism in additive manufacturing refers to the process by which individual layers of a 3D printed object are joined together to create a cohesive whole. Additive manufacturing techniques such as Fused Deposition Modeling (FDM), Stereolithography (SLA), and Selective Laser Sintering (SLS) rely on a variety of bonding mechanisms to ensure that each layer of the object is firmly attached to the previous layer

Explain Governing bonding mechanism in 3D printing

Governing bonding mechanism in 3D printing refers to the way in which the layers of the printed part are bonded together to create a solid structure. There are several different bonding mechanisms used in 3D printing, and the choice of mechanism depends on the type of printer and the material being used.

- Material Extrusion: In material extrusion (FDM) 3D printing, the bonding mechanism is based on the melting and fusing of the thermoplastic material. As the printer head moves over the build platform, it extrudes melted material through a nozzle, which solidifies and bonds to the previous layer.
- Powder Bed Fusion: In powder bed fusion 3D printing, such as selective laser sintering (SLS) and electron beam melting (EBM), the bonding mechanism is based on the melting or sintering of a powder material. A laser or electron beam is used to selectively melt or fuse the powder particles together, layer by layer, to create a solid structure.
- VAT Photopolymerization: In vat photopolymerization 3D printing, such as stereolithography (SLA) and digital light processing (DLP), the bonding mechanism is based on the curing of a liquid resin using light. A laser or projector is used to selectively cure the resin layer by layer, creating a solid structure.

Explain Post- Processing in Additive Manufacturing.

Post-processing in additive manufacturing refers to the additional steps or processes that take place after the 3D printing process has been completed. These

processes are designed to improve the physical properties, surface finish, and overall quality of the printed part.

There are several post-processing techniques used in additive manufacturing, including:

- **Cleaning:** This involves removing any support materials or residue left over from the printing process. Parts are typically washed or chemically treated to remove any excess material.
- **Surface treatment:** This includes sanding, polishing, or coating the surface of the printed part to improve its aesthetic appearance, reduce roughness, and enhance its functionality. Surface treatment can also improve adhesion properties and provide protection against environmental factors such as corrosion or wear.
- **Painting and coloring:** 3D printed parts can be painted or colored using a variety of techniques, such as spray painting, airbrushing, or dyeing. This can add color to the part, enhance its aesthetic appearance, or provide additional functionality, such as reflective properties.
- **Assembly:** In some cases, 3D printed parts may need to be assembled with other components to create a final product. Post-processing may involve connecting parts together, welding or bonding components, or adding hardware such as screws, nuts, or bolts.
- **Heat treatment:** Certain materials, such as metal alloys, may require additional heat treatment after the printing process to improve their mechanical properties. This can include annealing, tempering, or quenching to improve the strength, durability, and ductility of the final part.

Overall, post-processing is an important aspect of additive manufacturing, as it can significantly improve the quality and functionality of the final printed part. By using the right post-processing techniques, manufacturers can achieve the desired surface finish, mechanical properties, and aesthetic appearance for their 3D printed parts.

Common Faults in 3D printing

Although 3D printing is a versatile and innovative technology, there are several faults that can occur during the printing process. Some of the most common faults in 3D printing include:

- **Warping:** This occurs when the corners or edges of a 3D printed object lift up or curl during the printing process. Warping can be caused by factors such as temperature fluctuations, poor adhesion to the build platform, or improper cooling.
- **Layer shifting:** This occurs when the layers of a 3D printed object are not aligned correctly, resulting in a finished product that is skewed or distorted. Layer shifting can be caused by a range of factors, including mechanical issues with the printer or software errors.
- **Under extrusion/over extrusion:** This occurs when the 3D printer fails to deposit the correct amount of material, resulting in gaps or inconsistencies in the finished object. Under extrusion may be caused by a clogged nozzle, while over extrusion may be caused by incorrect temperature settings or excessive print speed.
- **Stringing:** This occurs when the printer leaves thin strands of material between different parts of the object. Stringing can be caused by improper retraction settings, which fail to pull the material back into the nozzle when it is not needed.
- **Poor surface finish:** This occurs when the surface of a 3D printed object is rough or bumpy, rather than smooth and uniform. Poor surface finish may be caused by a range of factors, including incorrect printer settings, low resolution, or incorrect material choice.

To avoid these faults, it is important to carefully calibrate the 3D printer and ensure that all settings are correctly configured before beginning the printing process. Regular maintenance and cleaning can also help to prevent issues such as clogged nozzles or improperly functioning components.

Troubleshooting Methods in 3D printing

When encountering faults in 3D printing, there are several troubleshooting methods that can be used to identify and address the issue. Some common troubleshooting methods include:

- **Adjusting print settings:** One of the first steps in troubleshooting is to review the print settings, such as the temperature, print speed, layer height, and infill density. Making adjustments to these settings can help to address issues such as warping or poor layer adhesion.

- Checking the print bed: Issues such as poor adhesion or warping can also be caused by an unlevel or dirty print bed. Checking and adjusting the print bed, or adding a layer of adhesive material, can help to resolve these issues.
- Inspecting the filament: Filament issues, such as tangled or improperly wound spools, can cause extrusion issues or under-extrusion. Checking the filament and ensuring it is properly loaded into the printer can help to address these issues.
- Reviewing the model: Issues with the 3D model, such as non-manifold geometry or incorrect slicer settings, can cause issues such as layer shifting or poor surface finish. Reviewing the model and adjusting settings can help to address these issues.
- Cleaning or replacing printer components: Over time, printer components such as the extruder nozzle or bed surface can become clogged or damaged. Regular cleaning or replacement of these components can help to ensure consistent printing performance.

Overall, effective troubleshooting in 3D printing requires a systematic approach and careful attention to detail. By identifying and addressing issues as they arise, it is possible to achieve high-quality 3D printed objects with minimal faults

Define Extrusion temperature

Extrusion temperature in 3D printing refers to the temperature at which the 3D printing material, typically a thermoplastic filament, is heated and melted by the printer's extruder before being deposited in layers to create a 3D object. The extrusion temperature can vary depending on the type of filament being used and the specific 3D printer model.

Explain the Process Design Post Processing requirements in 3D printing

The post-processing requirements for 3D printed objects depend on the desired final outcome and the specific material used in the printing process. However, there are some common post-processing requirements that apply to most 3D printing projects, including:

- Cleaning: After the printing process is complete, the object should be thoroughly cleaned to remove any excess support material or debris. This can be done using tools such as brushes, tweezers, or compressed air.

- Support removal: Many 3D printed objects require support structures during the printing process to prevent deformation or collapse. These supports must be carefully removed after printing, using tools such as pliers, wire cutters, or knives.
- Surface treatment: Depending on the material used and the desired finish, the surface of the printed object may need to be treated using sanding, polishing, or chemical processes.
- Painting or finishing: To improve the appearance of the printed object and protect it from wear and tear, it may be necessary to apply a coat of paint or a finishing treatment.
- Assembly: In some cases, multiple parts may need to be printed separately and then assembled using adhesives or other methods.

Overall, the post-processing requirements for 3D printing involve a combination of technical skills, tools, and materials. By carefully considering the desired outcome and following best practices for post-processing, it is possible to achieve high-quality, functional 3D printed objects.

Explain Process Design Post Processing techniques in 3D printing

Post-processing techniques are critical to achieving high-quality 3D printed objects. Some of the most common post-processing techniques in 3D printing include:

- Sanding and polishing: This involves using sandpaper, files, or polishing compounds to smooth out the surface of the printed object, removing any visible layer lines and creating a more refined finish.
- Painting and finishing: Painting or applying a finishing coat can help to improve the appearance and protect the object. Depending on the material used and application, different types of paint or finishing techniques may be used, such as spray painting or applying a clear coat.
- Vapor smoothing: This process involves exposing the printed object to a vaporized solvent, which melts the surface layer of the material and creates a smoother, more uniform finish.
- Support structure removal: Many 3D printed objects require support structures during the printing process to prevent deformation or collapse. These supports must be removed after printing, using tools such as pliers or wire cutters.

- Post-curing: For materials such as photopolymer resins used in stereolithography (SLA) 3D printing, post-curing involves exposing the printed object to UV light to fully cure and harden the material.
- Surface coating: Applying a coating to the surface of the printed object can provide additional protection, improve durability, and enhance the appearance. Examples include applying a clear coat, adding texture or applying a conductive coating.

These techniques can be used alone or in combination to achieve the desired results. By carefully considering the material used, the object's purpose, and the desired outcome, post-processing can help to achieve high-quality, functional 3D printed objects.

List methods for inspection and testing in 3d printing

Inspection and testing methods are essential in ensuring the quality and accuracy of 3D printed objects. Some of the most common inspection and testing methods used in 3D printing include:

- Visual inspection: A visual inspection involves examining the printed object for any visible defects or imperfections, such as layer lines or warping.
- Dimensional measurement: This involves measuring the dimensions of the printed object to ensure that it meets the required specifications. This can be done using calipers, micrometers, or other measuring tools.
- Mechanical testing: Mechanical testing involves subjecting the printed object to different types of physical stress to determine its strength and durability. This can be done through compression, tensile, or flexural testing.
- Material testing: Material testing involves testing the properties of the material used in the printing process, such as tensile strength, elongation, and stiffness.
- X-ray inspection: X-ray inspection is a non-destructive testing method that can detect any internal defects or porosity in the printed object.
- CT scanning: CT scanning is another non-destructive testing method that can provide a detailed 3D image of the internal structure of the printed object.
- Spectroscopy: Spectroscopy is a technique that can be used to analyze the chemical composition of the printed object.

These inspection and testing methods can be used alone or in combination to ensure the quality and accuracy of 3D printed objects. By carefully considering the specific requirements of the project, the appropriate inspection and testing methods can be selected to ensure that the final product meets the desired specifications.

List the Defects and their causes in 3d printing

There are several defects that can occur during the 3D printing process, which can negatively affect the quality of the final product. Some of the most common defects and their causes in 3D printing include:

- **Warping:** Warping occurs when the edges of the printed object start to curl or lift away from the build plate. This can be caused by uneven cooling, poor adhesion between layers, or incorrect printing temperatures.
- **Layer shifting:** Layer shifting occurs when the layers of the printed object are not aligned correctly. This can be caused by mechanical issues with the printer, such as loose belts or pulleys.
- **Stringing:** Stringing occurs when small strands of material are left behind between different parts of the printed object. This can be caused by incorrect temperature or printing speed settings.
- **Over-extrusion or under-extrusion:** Over-extrusion occurs when too much material is extruded, causing the printed object to have excess material or blobbing. Under-extrusion occurs when not enough material is extruded, resulting in gaps or weak spots in the printed object.
- **Inconsistent layer height:** Inconsistent layer height occurs when the layer thickness of the printed object is not consistent. This can be caused by issues with the printer calibration or incorrect settings.
- **Voids or gaps:** Voids or gaps occur when there are missing layers or areas of the printed object that are not fully filled with material. This can be caused by incorrect printing settings, such as too low of a printing temperature.
- **Surface roughness:** Surface roughness occurs when the surface of the printed object is not smooth or has visible layer lines. This can be caused by incorrect printing settings or a lack of post-processing techniques.

By understanding these common defects and their causes, 3D printing professionals can identify and troubleshoot issues as they arise, resulting in higher quality and more accurate printed objects.

Define Curing -

Curing (or post-curing, as some people call it) is the process of applying UV light and heat to improve the stability and strength of 3D printed images. This process is particularly important for Stereolithography (SLA) 3D printing, which uses functional UV-sensitive resin.

Questions:

- *Explain the Design and Process Parameters in 3D printing.*
- ***Define bonding Mechanism in additive manufacturing.***
- *Explain Governing bonding mechanism in 3D printing.*
- ***Explain Post- Processing in Additive Manufacturing.***
- ***List and explain the Common Faults in 3D printing.***
- ***Explain in detail Troubleshooting Methods in 3D printing.***
- ***Define Extrusion temperature.***
- *Explain the Process Design Post Processing requirements in 3D printing.*
- *Explain Process Design Post Processing techniques in 3d printing*
- ***Explain methods for inspection and testing in 3d printing.***
- *List the Defects and their causes in 3d printing*
- ***Define Curing***