Mechanical post-processing metal additive manufacturing

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STRENGTHENING THE EXCELLENCE OF ADDITIVE MANUFACTURING CAPABILITIES

Post-Processing

1 DESIGN
A thorough review of the designis conducted. Support structure placement and part orientation are determined.

2 BUILD
The material is loaded into the machine and the build begins. Starting with the first support structures, the metal powder is sintered one 20 or 30 micron layer at a time.

3 STRESS RELIEF
While still attached to the build plate, parts are placed inside a furnace to receive heat treatment based on the material's ASTM standard.

4 SUPPORT REMOVAL
Parts are machined off the build plate with wire EDM or a band saw. Support structures are removed from each part with hand tools.

5 FINISHING
When additional finishing is required, parts are sent to the CNC machine room for additional processing to achieve tighter tolerances or improved surface finish on critical features.

6 HEAT TREATMENT
More advanced heat treatment processes are performed to further improve material properties.

7 INSPECTION
Parts are inspected to validate dimensional accuracy and ensure conformance with the supplied drawing.

8 SHIPMENT
Individual geometries are bagged by part number and shipped to customer.

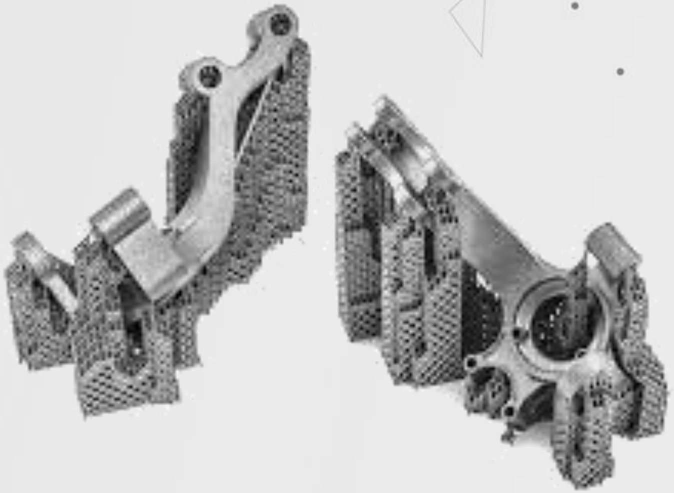
Technological approaches

Mechanical post-processing for additive manufacturing (AM) refers to the steps taken after the 3D printing process to improve the final part's surface finish, accuracy, and mechanical properties. Additive manufacturing technologies like 3D printing can produce parts with **layer lines, rough surfaces, and other imperfections.** Mechanical post-processing helps address these issues and enhance the overall quality of the printed parts.

Tools for post processing

Supports removal tools

Tools for post processing



Grinding tools

Sanding and Grinding

Manual sanding and grinding can help smooth out rough surfaces and eliminate visible layer lines. This is a common post-processing step for both plastic and metal 3D-printed parts.

After grinding the surface is still rough, and the color is not uniform. Sandblasting is necessary to be performed. After sandblasting, the surface is relatively smooth and uniform in color.

Shot Peening/Blasting

Shot peening involves blasting the surface of a part with small, high-velocity particles to improve **surface finish, relieve stress, and enhance fatigue resistance**. It is often used for metal parts

Shot-peening cabinet

Shot Peening/Blasting

Blasting Media

➢ Nutshells	Cleaning, brightening of the surface
➢ Ceramics	Surface compression, metallic-matt surface, shiny look
➢ Steel beads	Surface compression, metallic surface, shiny look
➢ Silicon carbide	Surface smoothing, matt look
➢ Aluminum oxide	Surface smoothing, matting, good for aluminum parts

Shot-peening cabinet

Shot Peening/Blasting

Blasting :
Cleaning, smoothing, changing appearance.

Initial step to homogenize the surface – DownSkin and UpSkin surfaces.

All agents(excluding nutshells): Reduction in UpSkin and SideSkin roughness = 30-65%

Ceramics: Reduction in DownSkin roughness up to 80%

Blasting can reduce the differences in roughness between DownSkin and UpSkin

Tumbling

Tumbling is a mechanical post-processing technique used in additive manufacturing (AM) to improve the surface finish and remove imperfections from 3D-printed parts. This method involves placing the printed parts in a rotating drum or container along with abrasive media, which then tumbles and agitates the parts to achieve the desired surface quality. Tumbling is particularly effective for small to medium-sized parts with complex geometries and can be used for both plastic and metal components.

Tumbling

1. Selection of Tumbling Media:

Tumbling media consists of small abrasive particles that help remove burrs, rough edges, and layer lines from the surface of 3D-printed parts. The choice of tumbling media depends on the material of the printed part and the desired finish. Common types of tumbling media include ceramic, plastic, and metal particles.

2. Loading the Parts and Media:

The 3D-printed parts are loaded into a rotating drum or container along with the selected tumbling media. The ratio of parts to media and the overall volume in the drum are important factors in achieving an effective and consistent tumbling process.

3. Rotating Drum or Container:

The drum or container is set in motion, causing the parts and tumbling media to move in a tumbling or cascading motion. The abrasive action of the media against the parts helps remove excess material, smooth surfaces, and eliminate imperfections.

Tumbling

4.Tumbling Duration:

The duration of the tumbling process depends on factors such as the material of the printed parts, the desired surface finish, and the type of tumbling media used. Tumbling times can vary from **minutes to several hours**.

5.Monitoring and Control:

The tumbling process is monitored to ensure that the desired surface finish is achieved without over-processing the parts. Control parameters such as rotation speed, tilt angle, and tumbling media size can be adjusted to optimize the results.

6.Cleaning and Inspection:

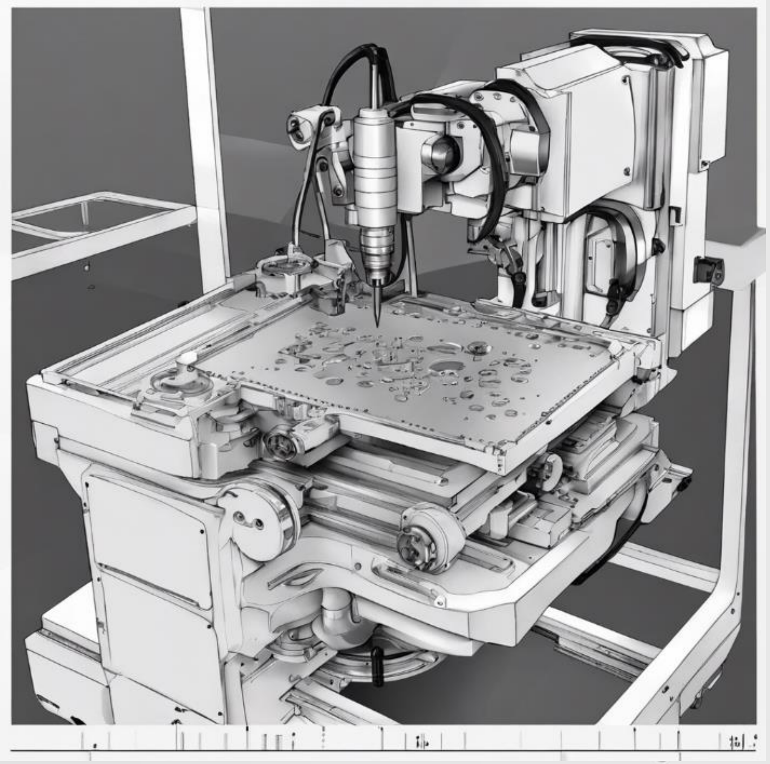
After tumbling, the parts are removed from the drum, and any remaining tumbling media is cleaned off. The parts are then inspected to ensure that the desired surface quality has been achieved.

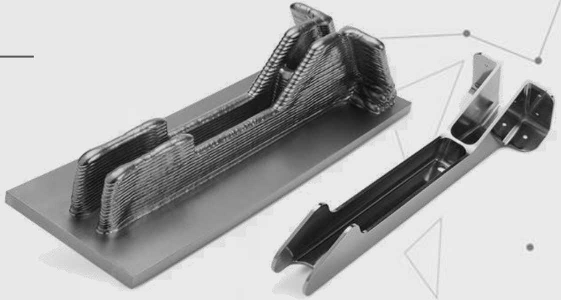
Tumbling

Benefits of Tumbling in Additive Manufacturing:

- **Surface Smoothing:** Tumbling effectively smooths out surface irregularities, layer lines, and other imperfections, resulting in a more refined finish.
- **Deburring:** The abrasive action of the tumbling media helps remove burrs and sharp edges, improving the overall safety and handling of the parts.
- **Consistency:** Tumbling provides a consistent surface finish across multiple parts, making it suitable for batch processing and ensuring uniform quality.
- **Complex Geometries:** Tumbling is particularly useful for parts with complex geometries or internal features that are challenging to access using other post-processing methods.

Machining





•**CNC Machining:** Computer Numerical Control (CNC) machining can be used to remove excess material and achieve tight tolerances on critical features. This is particularly useful for metal 3D-printed parts.

•**Turning and Milling:** Parts can be mounted on a lathe or milling machine to achieve specific surface finishes and dimensional accuracy.

Polishing

Polishing in 3D printing is a post-processing technique to improve the surface finish of 3D-printed parts. The goal of polishing is to smooth out layer lines, reduce roughness, and enhance the overall appearance of the printed object. Polishing is particularly relevant for parts that require a more refined and aesthetically pleasing finish

Polishing is a valuable step in post-processing 3D-printed parts, especially when a high-quality, refined finish is desired. The choice of polishing method depends on the material, geometry, and intended application of the printed object.

Polishing

1. **Material Compatibility:**
   The effectiveness of polishing can vary depending on the material used for 3D printing.
2. **Geometry and Complexity:**
   The geometry and complexity of the printed part influence the accessibility of surfaces for polishing. Parts with intricate details or internal structures may require specialized approaches.
3. **Layer Height and Resolution:**
   Parts with finer layer heights and higher resolution may require less aggressive polishing, as the layer lines are inherently less pronounced.

Chemical Polishing

Chemical polishing is a post-processing technique used in additive manufacturing (AM) to improve the surface finish of 3D-printed parts, particularly those made from metals. This method involves the immersion of the printed part in a chemical bath that removes material from the outer layer, resulting in a smoother and more polished surface.

It's important to note that the specific parameters of the chemical polishing process, including the choice of chemicals, immersion time, and temperature, should be carefully optimized based on the material and geometry of the 3D-printed part.

Chemical Polishing

1. **Selecting the Chemical Bath:**
   The choice of the chemical bath depends on the material of the 3D-printed part. Different metals and alloys may require different chemical solutions. Commonly used chemical solutions include acids or alkaline solutions.
2. **Preparation of the Part:**
   Before chemical polishing, the 3D-printed part needs to be cleaned thoroughly to remove any contaminants, support material residues, or other debris. This ensures that the chemical bath can effectively interact with the part's surface.
3. **Immersion in the Chemical Bath:**
   The cleaned part is then immersed in the chemical bath for a specific duration. The chemical solution reacts with the outer layer of the part, selectively dissolving or etching the surface.
4. **Controlled Material Removal:**
   The chemical polishing process is carefully controlled to achieve the desired level of material removal. The goal is to smooth out surface irregularities, layer lines, and other imperfections without compromising the dimensional accuracy of the part.

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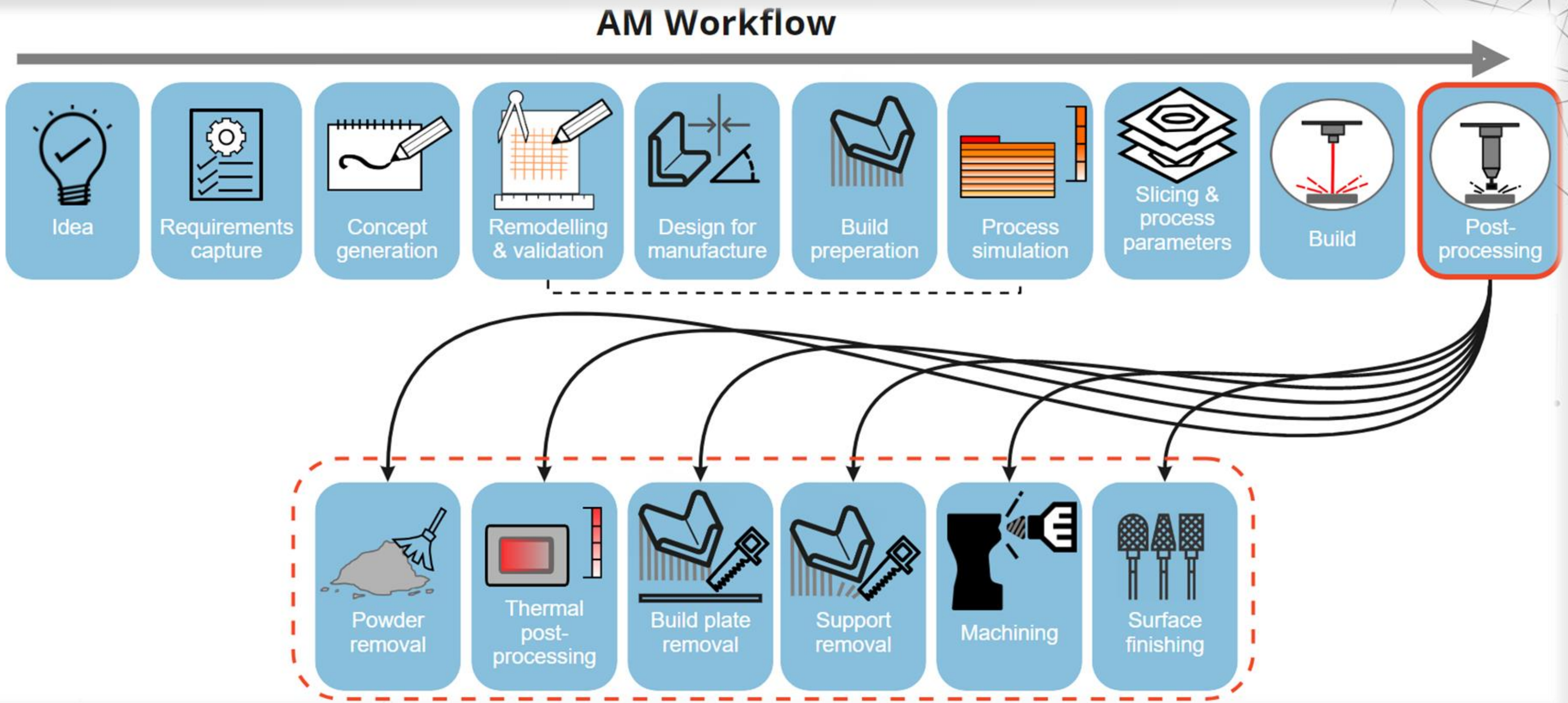
2. **Rinsing and Neutralizing:**
   After the immersion in the chemical bath, the part is thoroughly rinsed to remove any remaining chemical residue. In some cases, a neutralizing agent may be used to ensure that the chemical reaction is completely halted.
3. **Drying and Inspection:**
   The chemically polished part is then dried and inspected for the desired surface finish. This step is crucial to ensure that the chemical polishing process has achieved the intended results without introducing defects or compromising the part's integrity.

Electro Polishing

The Electro polishing is similar to chemical polishing in that the part is immersed in a chemical solution, the difference is that electropolishing applies an electric current to the workpiece's surface that dissolves its metal ions into the electrolytic medium. The addition of an electric current allows for greater control over the amount of surface metal removed.


AM Workflow
Idea
Requirements capture
Concept generation
Remodelling & validation
Design for manufacture
Build preperation
Process simulation
Slicing & process parameters
Build
Post-processing
Powder removal
Thermal post-processing
Build plate removal
Support removal
Machining
Surface finishing

Surface coating

Surface coating in additive manufacturing (AM) involves applying a thin layer of material onto the surface of 3D-printed parts to achieve specific properties or improve their performance. While the additive manufacturing process itself can produce complex and customized geometries, surface coatings are often applied to address certain limitations, enhance functionality, or provide additional features.

Surface coating

1. **Surface Finish Improvement:**
   Coatings can be applied to smooth out rough surfaces and reduce or eliminate visible layer lines created during the 3D printing process. This is especially relevant for parts where a high-quality, polished appearance is required.
2. **Wear Resistance:**
   Certain coatings, such as those made of ceramics or hard polymers, can be applied to enhance the wear resistance of 3D-printed parts. This is particularly useful for components subjected to friction, abrasion, or harsh environments.
3. **Corrosion Protection:**
   Metals and metal alloys used in additive manufacturing may benefit from coatings that provide corrosion resistance. This is important for parts exposed to moisture, chemicals, or corrosive substances.
4. **Biocompatibility:**
   Coatings can be applied to make 3D-printed medical implants or devices more biocompatible. This is crucial for ensuring that the materials used do not negatively interact with biological tissues.
5. **Functional Properties:**
   Surface coatings can introduce specific functional properties to a part, such as electrical conductivity, thermal insulation, or magnetic properties. This is particularly relevant for applications where these properties are essential.

THANKS