SNS COLLEGE OF TECHNOLOGY

Department of Mechanical Engineering

19MEE307 Additive Manufacturing

UNIT III PHOTO POLYMERIZATION AND POWDER BED FUSION PROCESSES

Theory:

Photo polymerization: SLA-Photo curable materials – Process - Advantages and Applications. Powder Bed Fusion: SLS-Process description – powder fusion mechanism – Process Parameters – Typical Materials and Application. Electron Beam Melting.

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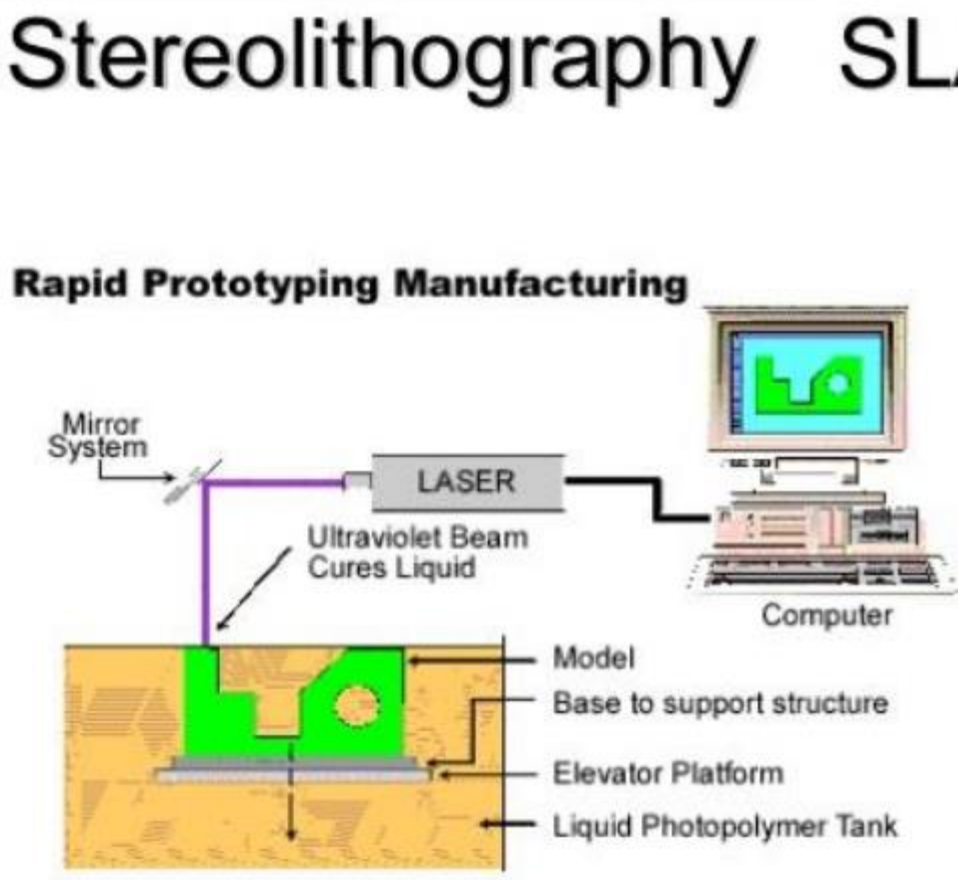
Forms of AM

Based on the form of Material Additive Manufacturing can be categorized into three (3) based :

1. Liquid-based
2. Solid based
3. Powder based

Stereo lithography

Stereo lithography is an additive manufacturing process using a vat of liquid UV-curable photopolymer " resin" and a UV laser to build parts a layer at a time. On each layer, the laser beam traces a part cross-section pattern on the surface of the liquid resin. Exposure to the UV laser light cures, or, solidifies the pattern traced on the resin and adheres it to the layer below.



Highlights of Stereo lithography

- The first RP technique and is still most widely used.
- Inexpensive compared to other techniques.
- Uses light-sensitive liquid polymer.
- Requires post-curing since laser is not of high enough power to complete.
- Long-term curing.
- Parts are quite brittle and have a tacky surface.
- Support structures are typically required.
- Process is simple: There are no milling or masking steps required.
- Uncured material can be toxic.

Process parameter

- The starting materials are liquid monomers
- Each layer is 0.076 mm to 0.50 mm (0.003 in to 0.020 in thick – Thinner layers provide better resolution and more intricate shapes; but processing time is longer
- Laser scan speeds typically 500 to 2500 mm/s

Stereolithography

Stereolithography is one of the more commonly used rapid manufacturing and rapid prototyping technologies.

It is considered to provide high accuracy and good surface finish.

It involves building plastic parts a layer at a time by tracing a laser beam on the surfa of a vat of liquid photopolymer.

The photopolymer is solidified by the laser light.

Once one layer is completely traced, it is lowered a small distance into the liquid and subsequent layer is traced, adhering to the previous layer.

After many such layers are traced, a complete 3D model is formed.

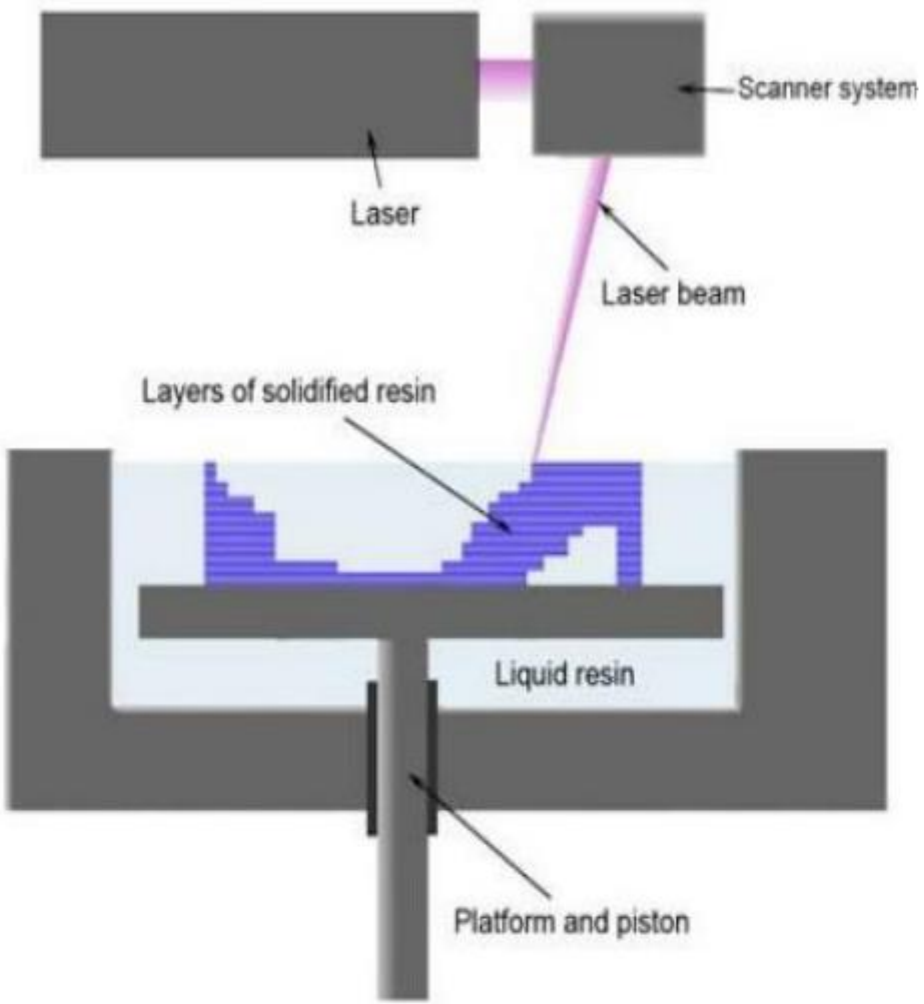
Some specific technologies require further curing of the polymer in an oven.

Some objects have overhangs or undercuts which must be supported during the fabrication process by support structures.

These are either manually or automatically designed and fabricated right along with the object.

Upon completion of the fabrication process, the object is elevated from the vat and the supports are cut off.

- Stereolithography is an additive process which uses vat of liquid UV-curable photopolymer "resin" and a UV laser to build parts a layer at a time.
- Exposure to the light cures the pattern traced on the resin and adheres it to the layer below.



Working of SLA

A moveable table, or elevator (A), initially is placed at a position just below the surface of a vat (B) filled with liquid photopolymer resin (C).

This material has the property that when light of the correct colo strikes it, it turns from a liquid to a solid.

The most common photopolymer materials used require an ultraviolet light, but resins that work with visible light are also utilized.

The system is sealed to prevent the escape of fumes from the resin.

Working

A laser beam is moved over the surface of the liquid photopolymer to trace the geometry of the cross-section of the object.

This causes the liquid to harden in areas where the laser strikes.

The laser beam is moved in the X-Y directions by a scanner system (D).

These are fast and highly controllable motors which drive mirrors and are guided by information from the CAD data.

The exact pattern that the laser traces is a combination of the information contained in the CAD system that describes the geometry of the object, and information from the rapid prototyping application software that optimizes the faithfulness of the fabricated object.

Of course, application software for every method of rapid prototyping modifies the CAD data in one way or another to provide for operation of the machinery and to compensate for shortcomings.

More recently pump-driven recoating systems have been utilized.

The tracing and recoating steps are repeated until the object is completely fabricated and sits on the table within the vat.

Some geometries of objects have overhangs or undercuts.

These must be supported during the fabrication process

The support structures are either manually or automatically designed.

Upon completion

The object is elevated from the vat and allowed to drain.

Excess resin is swabbed manually from the surfaces.

The object is often given a final cure by bathing it in intense light in a box resembling an oven called a Post-Curing Apparatus (PCA).

Some resins and types of stereolithography equipment don't require this operation, however. After final cure, supports are cut off the object and surfaces are sanded or otherwise finished.

Stereo lithography generally is considered to provide the greatest accuracy and best surface finish of any rapid prototyping technology.

Work continues to provide materials that have wider and more directly useable mechanical properties.

Photopolymers

There are many types of liquid photopolymers - solidified by exposure to electro-magnetic radiation, including wavelengths in the gamma rays, X-rays, UV and visible range, or electron-beam (EB)

UV-curable photopolymers are resins

There are a large variety of them and some may contain fillers and other chemical modifiers to meet specified chemical and mechanical requirements The process through which photopolymers are cured is referred to as the photopolymerization process.

Composition_1

1)Binders

A binder is an ingredient used to bind together two or more other materials in mixtures. Its two principal properties are adhesion and cohesion. This material consists of long, chain-like, chemically-reactive molecules that give the final solid its mechanical and other properties.

Examples include acrylates, epoxies and urethanes. Most of a photopolymer consists of these binders which might typically be in the range of 50 to 80% of the total weight.

Composition_2

Monomers A monomer (from Greek mono "one" and meros "part") is an atom or a small molecule that may bind chemically to other monomers to form a polymer. Some examples include vinyls and shorter acrylate molecules. Monomers may typically constitute 10 to 40% of the photopolymer.

Photo initiators

Photo initiators are molecules that can be split into two or more parts by exposure to light.

At least one of these parts is capable of reacting with both the monomers and binders to link them together.

Photo initiators are only sensitive to specific wavelengths of light.

The free-radical photo polymerization process Photo initiator molecules, Pi, which are mixed with the monomers, M, are exposed to a UV source of actinic photons, with energy of hv . The photo initiators absorb some of the photons and are in an excited state. Some of these are converted into reactive initiator molecules, P•, after undergoing several complex chemical energy transformation steps. These molecules then react with a monomer molecule to form a polymerization initiating molecule, PM•. This is the chain initiation step. Once activated, additional monomer molecules go on to react in the chain propagation step, forming longer molecules, PMMM• until a chain inhibition process terminates the polymerization reaction

Advantages and Disadvantages

The main advantages of using SLA are:

(1) Round the clock operation. The SLA can be used continuously and nattended round the clock.

(2) Good user support. The computerized process serves as a good ser support.

(3) Build volumes. The different SLA machines have build volumes ranging fron small to large to suit the needs of different users.

(4) Good accuracy. The SLA has good accuracy and can thus be used or many application areas.

(5) Surface finish. The SLA can obtain one of the best surface finishes amongst RP technologies.

Wide range of materials.

There is a wide range of materials….The main disadvantages of using SLA are:

(1) Requires support structures. Structures that have overhangs and undercuts must have supp
that are designed and fabricated together with the main structure.

(2) Requires post-processing. Post-processing includes removal of supports and other unwante
materials, which is tedious, time consuming and can damage the model.

(3) Requires post-curing. Post-curing may be needed to cure the object completely and ensure
integrity of the structure.

Applications

The SLA technology provide methods for reducing time to market, lowering product development costs, gaining greater control of their design process and improving product design.

(1) Models for conceptualization(an elaborated concept), packaging and presentation.

(2) Prototypes for design, analysis, verify ,functional testing.

(3) Parts for prototype tooling and low volume production tooling.

(4) Investment casting, sand casting and molding.

(5) Tools for fixture and tooling design, and production tooling

Thank you