



SLS – Selective Laser Sintering

DR. M.ELANGO VAN

16ME420



SLS

SLS is a rapid prototyping (RP) process that builds models from a wide variety of materials using an additive fabrication method.

The build media for SLS comes in powder form, which is fused together by a powerful carbon dioxide laser to form the final product



The company

The Selective Laser Sintering (SLS) process was developed by The University of Texas in Austin, and was commercialized by DTM, Corporation out of Austin, TX in 1987 with support from B.F. Goodrich.

The first SLS system was shipped in 1992, and there are currently several systems in use worldwide.



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SLS currently has 10 different build materials that can be used within the same machine for a wide variety of applications

The SLS process begins, like most other RP processes, with the standard .STL CAD file format, which is exported now by most 3D CAD packages



SLS – MECHANISM

Moving laser beam sinters heat-fusible powders in areas corresponding to the CAD geometry model one layer at a time to build the solid part

After each layer is completed, a new layer of loose powders is spread across the surface

Layer by layer, the powders are gradually bonded by the laser beam into a solid mass that forms the 3-D part geometry

In areas not sintered, the powders are loose and can be poured out of completed part



Powder bed on Build position Excess powder take-up Powder-levelling
roller Built part Powder feed CO2 Laser Scanning system Temperature-
controlled Build Chamber with Nitrogen atmosphere SLS – Mechanism



MATERIAL THAT CAN BE USED:

1. Plastic powders
2. Metal powders (direct metal laser sintering),
3. Ceramic powders
4. Glass powders



Patented in 1989.

Considerably stronger than SLA; sometimes structurally functional parts are possible.

Advantage over SLA: Variety of materials and ability to approximate common engineering plastic materials.

Process is simple: There is no milling or masking steps required

Living hinges are possible with the thermoplastic-like materials

Powdery, porous surface unless sealant is used

Sealant also strengthens part

Uncured material is easily removed after a build by brushing or blowing it off.



SLA vs SLS

SLA SLS A SUMMARIZED COMPARISON Material Properties:

The SLA process is limited to photosensitive resins which are typically brittle.

The SLS process can utilize polymer powders that, when sintered, approximate thermoplastics quite well.



Surface Finish

The surface of an SLS part is powdery, like the base material whose particles are fused together without complete melting.

The smoother surface of an SLA part typically wins over SLS when an appearance model is desired.

In addition, if the temperature of uncured SLS powder gets too high, excess fused material can collect on the part surface.

This can be difficult to control since there are so many variables in the SLS process.

In general, SLA is a better process where fine, accurate detail is required. However, a varnish- like coating can be applied to SLS parts to seal and strengthen them



Dimensional Accuracy:

SLA is more accurate immediately after completion of the model, but SLS is less prone to residual stresses that are caused by long-term curing and environmental stresses.

The temperature dependence of the SLS process can sometimes result in excess material fusing to the surface of the model

SLA parts suffer from the "trapped volume" problem in which cups in the structure that hold fluid cause inaccuracies.

SLS parts do not have this problem



Support Structures:

SLA parts typically need support structures during the build.

SLS parts, because of the supporting powder, sometimes do not need any support, but this depends upon part configuration.

Marks left after removal of support structures for parts cause dimensional inaccuracies and cosmetic blemishes.



DATA PREPARATION FOR SLS

The SLS technology is housed in the Sinterstation line of systems by DTM.

The current model is the Sinterstation 2500, which has various improvements over its predecessor, the Sinterstation 2000.

Figure shows the Sinterstation 2500 Sinterstation 2500



SLS process

The SLS process begins, like most other RP processes, with the standard .STL CAD file format, which is exported now by most 3D CAD packages

The DTMView software can import one or several .STL files, and allows you to orient or scale the parts as you see necessary

The 2500 systems have "auto-nesting" capabilities, which will place multiple parts optimally in the build chamber for the best processing speed and results.

Once the .STL files are placed and processing parameters are set, the models are built directly from the file



With the build piston at the top, a thin layer of powder is spread across the build area by a roller/sweeper from one of the feed pistons.

The laser then cures in a raster sweep motion the cross-sectional area of the parts being built



PROCESS PARAMETERS

1. Part bed temperature
2. Layer thickness
3. Laser power : The longer the laser dwells in a particular location, the deeper the fusion depth and the larger the melt pool diameter. Typical layer thicknesses range from 0.1 to 0.15 mm
4. Laser scan speed
5. Energy density
6. Powder shape



Process parameters

Process parameters can be lumped into four categories:

- (1) laser-related parameters (laser power, spot size, pulse duration, pulse frequency, etc.),
- (2) scan-related parameters (scan speed, scan spacing, and scan pattern),
- (3) powder-related parameters (particle shape, size and distribution, powder bed density, layer thickness, material properties, etc.),
- (4) temperature-related parameters (powder bed temperature, powder feeder temperature, temperature uniformity, etc.)



Part bed temperature

- The part bed is the central region of the SLS machine (DTM Sinterstation 2000) where the part is built
- The part bed temperature is controlled by the heater underneath the build area
- the temperature should be lower than melting temperature of the powder
- The higher the temperature is set, the less the incident energy is required during the SLS process



Layer thickness

- Layer thickness is a measure of the thickness of each layer during the SLS process
- It is also the depth by which the part piston is lowered after the laser scanning of each layer
- A thicker layer requires greater incident energy
- Thicker layers will not give us very good surface finish because of 'stair stepping'



Energy Density:

- Energy density is defined as the amount of energy input per unit area
- It is dependent upon laser power, scan speed and scan spacing and is determined by the following equation
- $ED = LP / (BS \times SS)$
- where ED is the energy density, LP is the laser power, BS is the beam scan speed and SS is the scan spacing.

The laser power, scan speed and scan spacing need to be optimized according to the amount of input energy required to fuse the particles in the layer



Selective Laser Sintering Applications

- Rapid Manufacturing
- Aerospace Hardware
- UAS, UAV, UUV, UGV Hardware
- Medical and Healthcare
- Electronics; Packaging, Connectors
- Homeland Security
- Military Hardware
- Rapid Prototypes:
- Functional Proof of Concept Prototypes
- Design Evaluation Models (Form, Fit & Function)
- Product Performance & Testing
- Engineering Design Verification
- Wind-Tunnel Test Models



Tooling and Patterns

Tooling and Patterns:

Rapid Tooling (concept development & bridge tools)

Injection Mould Inserts

Tooling and Manufacturing Estimating Visual Aid

Investment Casting Patterns

Jigs and Fixtures

Foundry Patterns - Sand Casting



ADVANTAGES AND DISADVANTAGES

Stereolithography offers a lot of advantage to a variety of business situations.

SLA parts have probably the best surface quality of all other RP systems, and are also highly competitive in dimensional accuracy.

Also, the latest SLA systems have significantly increased the speed at which parts can be produced, which is ultimately the goal of RP.

Finely detailed features, like thin vertical walls, sharp corners, and tall columns can be fabricated with ease even on older SLA systems, and the growing list of available resins are pushing the envelope on temperature and strength characteristics as well



Disadvantages

The main disadvantage of the SLA process is most likely the Postprocessing requirements.

Although significant advances have been made to make working materials safer and easier to work with, procedures to handle raw materials for the SLA still require careful and aware practices.

Another disadvantage, which may decrease as resin competition increases, is the relatively high cost of photocurable resins, weighing in at around \$600 to \$800 per gallon.