UNIT – I

INTRODUCTION TO 3D PRINTING

Selective Laser Sintering 3D Printing

Selective laser sintering is an additive manufacturing (AM) technology that uses a high-power laser to sinter small particles of polymer powder into a solid structure based on a 3D model.

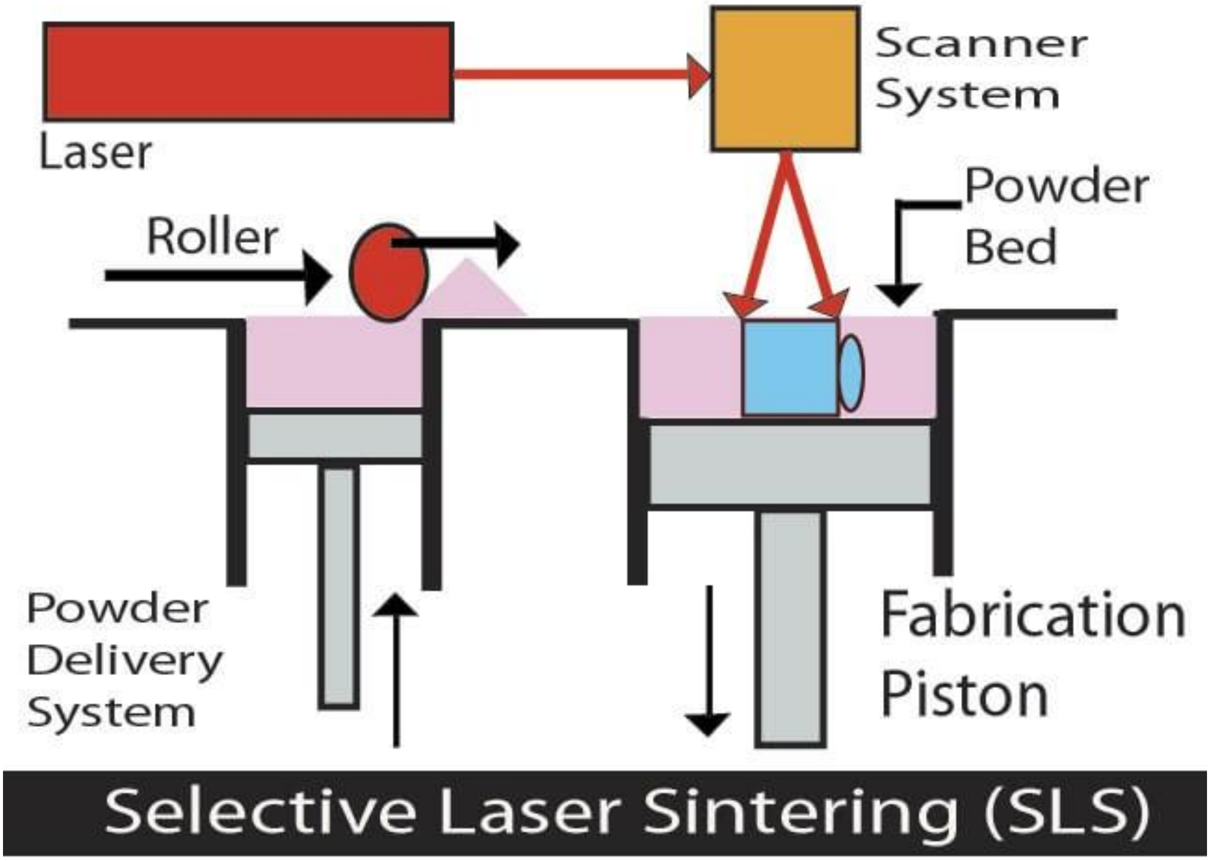
SLS 3D printing has been a popular choice for engineers and manufacturers for decades. Low cost per part, high productivity, and established materials make the technology ideal for a range of applications from rapid prototyping to small-batch, bridge, or custom manufacturing.

Recent advances in machinery, materials, and software have made SLS printing accessible to a wider range of businesses, enabling more and more companies to use these tools that were previously limited to a few high-tech industries.

How SLS 3D Printing Works

1. **Printing:** The powder is dispersed in a thin layer on top of a platform inside of the build chamber. The printer preheats the powder to a temperature somewhat below the melting point of the raw material, which makes it easier for the laser to raise the temperature of specific regions of the powder bed as it traces the model to solidify a part. The laser scans a cross-section of the 3D model, heating the powder to just below or right at the melting point of the material. This fuses the particles together mechanically to create one solid part. The unfused powder supports the part during printing and eliminates the need for dedicated support structures. The platform then lowers by one layer into the build chamber, typically between 50 to 200 microns, and the process repeats for each layer until parts are complete.
2. **Cooling:** After printing, the build chamber needs to slightly cool down inside the print enclosure and then outside the printer to ensure optimal mechanical properties and avoid warping in parts.

3. **Post-processing:** The finished parts need to be removed from the build chamber, separated, and cleaned of excess powder. The powder can be recycled and the printed parts can be further post-processed by media blasting or media tumbling.



SLS 3D Printing Materials

The most common material for selective laser sintering is nylon, a highly capable engineering thermoplastic for both functional prototyping and end-use production. Nylon is ideal for complex assemblies and durable parts with high environmental stability.

SLS 3D printed nylon parts are strong, stiff, sturdy, and durable. The final parts are impact-resistant and can endure repeated wear and tear. Nylon is resistant to UV, light, heat, moisture, solvents, temperature, and water. 3D printed nylon parts can also be biocompatible and not sensitizing, which means that they are ready to wear and safe to use in many contexts.

Nylon is a synthetic thermoplastic polymer that belongs to the family of polyamides. It is available in multiple variants, each tailored to different applications. Nylon 12 Powder and Nylon 11 Powder are single-component powders, while Nylon 12 GF Powder is a glass-filled composite, and Nylon 11 CF Powder is a carbon fiber reinforced composite. These composite materials are developed to optimize parts for higher strength, stiffness, or flexibility. With these two-component powders, only the component with the lower glass transition point is sintered, binding both components.

SLS 3D printers can also create flexible **TPU** parts with unmatched design freedom and ease. Combining the high tear strength and elongation at break of rubber materials with the versatility of SLS 3D printing, TPU is ideal for producing flexible, skin-safe prototypes and end-use parts that withstand the demands of everyday use.

SLS 3D Printing Workflow

1. Design and Prepare the File

Use any CAD software or 3D scan data to design your model, and export it in a 3D printable file format (STL or OBJ). Each SLS printer includes software to specify printing settings, orient and arrange models, estimate print times, and slice the digital model into layers for printing. Once setup is complete, the print preparation software sends the instructions to the printer via a wireless or cable connection.

2. Prepare the Printer

The workflow for preparing the printer varies by system. Most traditional SLS systems require extensive training, tools, and physical effort to prepare and maintain.

Fuse Series printers reimagine the SLS workflow for simplicity and efficiency, with modular components to enable nonstop printing and end-to-end powder handling.

3. Print

Once all preprint checks have been completed, the machine is ready to print. SLS 3D prints can take anywhere from a few hours to multiple days depending on the size and complexity of parts, as well as the part density.

Once the print is finished, the build chamber needs to slightly cool down in the print enclosure before moving to the next step. After that, the build chamber can be removed and a new one inserted to run another print. The build chamber has to cool down before post-processing to ensure the optimal mechanical properties and avoid warping in parts. This may take up to half of the print time.

4. Part Recovery and Post-Processing

Post-processing SLS parts requires minimal time and labor compared to other 3D printing processes. It is easily scalable and yields consistent results for batches of parts thanks to the lack of support structures.

After a print job is complete, remove the finished parts from the build chamber, separate them, and clean them of excess powder. This process is typically completed manually at a cleaning station using compressed air or a media blaster.

Any excess powder remaining after part recovery is filtered to remove larger particles and can be recycled. Unfused powder degrades slightly with exposure to high temperatures, so it should be refreshed with new material for subsequent print jobs. This ability to re-use the material for subsequent jobs makes SLS one of the least wasteful manufacturing methods.

A common theme in the SLS industry is to offer separate devices for reclaiming, storing, and mixing powder. In the Fuse Series workflow, a single device, Fuse Sift, handles the extraction of parts and unsintered powder, as well as storing, dosing, and mixing of streams.

5. Additional Post-Processing

SLS 3D printed parts are ready to use after sifting. However, there are several other advanced SLS post-processing methods that you might consider.

By default, SLS 3D prints have a grainy finish. Formlabs recommends media blasting or media tumbling SLS parts for a smoother surface finish. Parts may be spray painted, lacquered, electroplated, and coated to achieve different colors, finishes, and properties, for example, watertightness (coating) and conductivity (electroplating). Formlabs SLS parts are dark in color, so they are not ideal for dyeing.

Benefits SLS has many benefits over traditional manufacturing techniques. Speed is the most obvious because no special tooling is required and parts can be built in a matter of hours. Additionally, SLS allows for more rigorous testing of prototypes. Since SLS can use most alloys, prototypes can now be functional hardware made out of the same material as production components. SLS is also one of the few additive manufacturing technologies being used in production. Since the components are built layer by layer, it is possible to design internal features and passages that could not be cast or otherwise machined. Complex geometries and assemblies with multiple components can be simplified to fewer parts with a more cost effective assembly. SLS does not require special tooling like castings, so it is convenient for short production runs. Applications This technology is used to manufacture direct parts for a variety of industries including aerospace, dental, medical and other industries that have small to medium size, highly complex parts and the tooling industry to make direct tooling inserts. With a build envelop of 250 x 250 x 185 mm, and the ability to 'grow' multiple parts at one time, SLS is a very cost and time effective technology. The technology is used both for rapid prototyping, as it decreases development time for new products, and production manufacturing as a cost saving method to simplify assemblies and complex geometries. Constraints The aspects of size, feature details and surface finish, as well as print through error in the Z axis may be factors that should be considered prior to the use of the technology. However, by planning the build in the machine where most features are built in the x and y axis as the material is laid down, the feature tolerances can be managed well. Surfaces usually have to be polished to achieve mirror or extremely smooth finishes. For production tooling, material density of a finished part or insert should be addressed prior to use. For example, in injection molding inserts, any surface imperfections will cause imperfections in the plastic part, and the inserts will have to mate with the base of the mold with temperature and surfaces to prevent problems. In this process metallic support structure removal and post processing of the part generated is a time consuming process and requires use of EDM and/or grinding machines having the same level of accuracy provided by the RP machine.