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Stereolithography Apparatus (SLA) Process

Stereolithography systems build shapes using light to selectively solidify photo-curable resins (photo-polymers). Presently, it is the most widely used RP (Rapid Prototyping) technology. The process was first developed and commercialized by 3D systems, California, U.S.A.

This technology today is capable of producing highly complex 3D geometries with little or no human intervention.

Overview of the Process

Stereolithography software interprets the CAD/CAM data and slices it into a series of thin horizontal layers. A controller then positions a platform (or elevator) housed in a container filled with liquid resin so that it rests just below the surface. An optical scanning system directs the layer, which "draws" the image one layer at a time on the surface of the resin. As the laser beam strikes each layer, the liquid resin is converted into a solid plastic. The platform (or elevator) then lowers the newly built layer, passively coats its surface with a new layer of resin, and the laser beam converts the liquid resin into a hard layer as it moves along the part contour. The process is repeated until the object is complete. The system is capable of working 24-hr unattended.

Using a passive recoating system, the machine is capable of producing complex shapes with intricate interior features.

Large models and patterns (e.g. door panels, cover plates) can be constructed in smaller portions and then bonded together to form a full-size part.

Applications of SAL Process

Automotive, aerospace, computer, electronic, architectural, appliances and consumer products and medical/healthcare products and services, at reduced cost, higher quality and saving in time.

The stereolithography can support JIT and concurrent engineering technologies also.

The product diversity ranges from concept models, plastic prototypes, soft tooling for silicone and sand moulds, patterns for casting (replacing lost-wax method) and tooling elements. Visualization of design, verification of engineering design changes, confirmation of fits, functions, interference and producibility (manufacturability) of complex parts can be carried out.

The following are general engineering and business applications/possibilities offered by SLA process:

- Accelerated conceptual design
- Quick turn-around of design iteration
- Quick design reviews
- Reduction in errors
- Early identification of manufacturing problems
- Higher product quality
- Immediate feedback from engineering teams
- Mould and pattern making (rapid tooling)
- Concept visualization of new products
- Low volume production is also made economical
- Reduced time-to-market (improves competitiveness).

Meaning of Stereolithography

Stereolithography is an important prototyping process. It is a process of fabricating 3D (3-Dimensional) objects from a smooth base plate that is specially prepared so that the material can be put layer by layer and part can be built.

Stereo means three-dimensional (i.e. 3D shapes are obtained through movement, of a scanning beam in three-directions), and lithography means a process of printing on a flat surface. Here printing of 3D shapes are done by melting the material by a laser source and the material is allowed to cure (i.e. to set) forming a shape.

Heat Source Used

The heat source used is a laser generating ultra-violet beam which is allowed to focus on the selected surface area of the photo-polymer and then moved in the X and Y direction to get the desired shape. The beam cures that portion of the photo-polymer/setting takes place and results in a solid structure.

Part Material

Stereolithography process is based on the principle of curing (hardening) of a liquid photo-polymer to a desired shape. The liquid is photo curable (i.e. cures when light beam falls on it). The liquid is an acrylate polymer, a mixture of acrylic monomers and a photo-initiator (to initiate the process of curing when light falls on it). The prototype part is made of this type of acrylic polymer (plastic).

The sequence of operations is explained with respect to different stages (levels) of the part being fabricated (Fig. 2.1).

a. Position in which the platform is in the highest position (starting of the process).

b. As the platform is lowered the photo-polymer material (liquid) is continuously heated (cured) by the laser beam and layer of thickness upto "b" is formed. "b" is the flange portion of the part being framed over the previously formed ring.

c. Completion of the process when the platform is moved completely down to get the desired thickness of the cylindrical component.

Working of SLA Equipment/Process Description

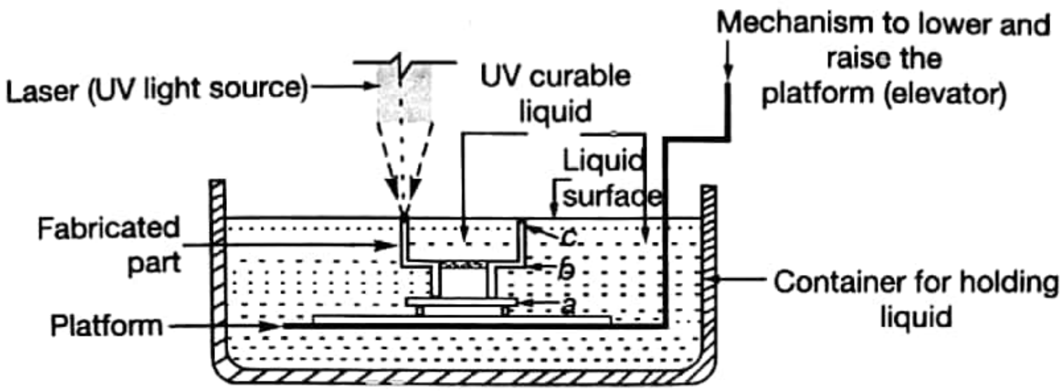

Fig. 2.1: Stereolithography Apparatus (Equipment) for Rapid Prototyping. (Computer-controlled laser beam curves a liquid thermosetting polymer)

The part is produced in "bottom-up" manner with individual slices of the material. If the flange portion is of large diameter, or for overhanging parts a support structure is required to serve as a base for the build up of the part.

The surrounding liquid is still fluid since it has not been cured yet. The unused portion of the liquid polymer can be used again later to produce another part or for another prototype.

After the completion of the process, the part is removed from the platform, liquid drained and cleaned using ultrasonic vibrations in a tank. Support structure, if any, is removed and final curing is done.

Process Capabilities/Advantages

- Tolerance/Accuracy = $\pm$ 0.01 mm. (This depends on the sharpness of the focus of the laser beam.)
- Surface finish is the best amongst all processes.
- Smooth surfaces can be obtained since focusing is quite precise due to use of laser beam.
- Oblique surfaces can also be obtained.
- Cycle time varies from a few hours to a day.
- Maximum part size: 500 cm × 500 cm × 600 cm (height).
- Model building can take place unattended.
- Capable of fine details of contour and thin walls.

- Material is toxic and hazardous.
- Part strength is less and may undergo warpage in presence of excess moisture.
- Post-curing of the part is required and may result in slight distortion.
- The material has a finite shelf-life and needs to be replaced (even if unused) after a period of about two years.
- The part becomes brittle over a period of time.

In some machines, there is a doctor-blade (wiper arm) mechanism which traverses the part surface quickly levelling the excess photo-polymer material.

Specification of SLA Machine

This will give an idea of machine's features and various sub-systems.

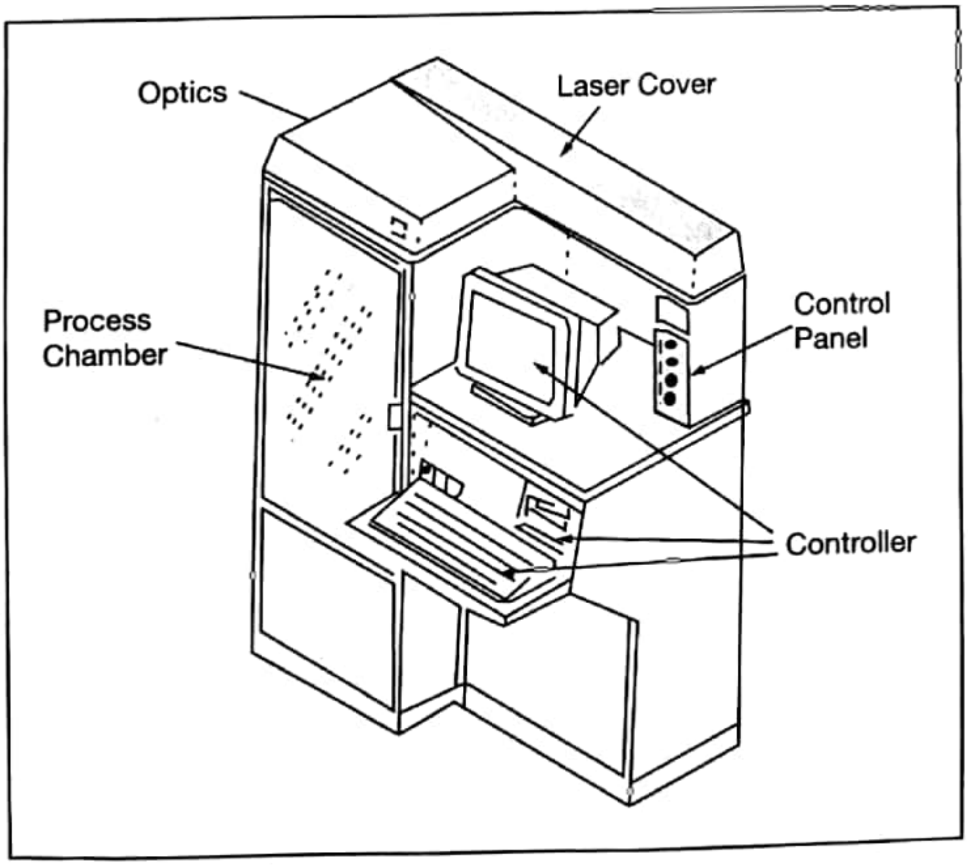

Fig. 2.3: Schematic diagram of SLA machine

Figure 2.3 shows schematic diagram of the machine showing sub-systems.

- Laser: - HeCd, Wavelength 325 nm
  - Power delivery 5 to 10 mW
  - Laser Life: 2000 hrs.
- Optical and Scanning: - Max. spot size: 0.3 mm
  - Spot location resolution: 0.01 mm
  - Spot location repeatability: 0.1 mm
  - Max. traverse speed: 400 mm/sec. (drawing speed)
- Platform (Elevator): - Vertical resolution: 0.01 mm
  - Position repeatability: 0.01 mm
  - Max. part weight: 5 kg
- Container (Tank): - Size: 200 mm × 200 mm × 250 mm deep (Max. size of part allowable)
  Capacity: 20 litres
- Recoating system: - Minimum layer thickness: 0.25 mm
- Computer control system: - Disk space (storage) 62.5 mb
  - 1/0 devices and capacity: 1.25 mb floppy drive
- Electrical power requirement: - 220 VAC ± 10%, 50 Hz, 8A
- Size of machine: - 1.25 m length × 0.7 m width
  1.75 m height (Floor space can be suitably provided for installing the machine)
- Weight: - 300 kg
- Environment (room temp.): - 20°C-26°C (Shields and interlocks provided for safety of operators)