MODULE – 1 :-
STEREO LITHOGRAPHY

Stereolithography, was the first Rapid prototyping process to reach the market in 1987. produced by 3D systems Corporation. Stereolithography system builds shapes using light to selectively solidify photocurable resins.

STEREOLITHOGRAPHY APPARATUS :

MODEL	250/30	5000	7000
Laser Type	Hecd	Solid state	Solid state
Laser power	12 mW	216 mW	800 mW
Laser Life	2,000 hrs	5,000 hrs	5,000 hrs.
Recoat	Blade	Zephyr	Zephyr
Min slice	0.006"	0.002"	0.001"
Beam diameter	0.008"	0.008"	Variable
Scan speed	30 in/sec	200 in/sec	Variable
Max part vol	10x10x10"	20x20x23"	20x20x23"
Max part wt.	20 lb	150 lb	150 lb.

The above table shows the approximate operating values of 3D system's Stereolithography machines.

STEREOLITHOGRAPHY SOFTWARE :

→ Since Inception of the original MS-DOS version, which operates SLA 250 and SLA 500 machines.

→ Three packages were required as a part of the software System.

* a UNIX-based system for viewing and positioning (SLA view)
* a UNIX-based third-party software for generating support structures (Bridge-Works)

* Finally the slicing and system operation software (SLA slice) located on the pc attached to the SLA machine.

→ The latest systems have microsoft windows software 3D Light year for viewing and positioning, support generation, and slicing; Build station for operating the SLA machine.

STEREOLITHOGRAPHY BUILD MATERIALS :

→ Stereolithography system build shapes using light to selectively solidify photocurable resins.

→ Stereolithography creates acrylic or epoxy parts directly from vat of liquid photocurable polymer by selectively solidifying the polymer with a scanning laser beam.

polymerization is the process of curing a plastic or polymer by introducing a catalyst. In other words polymerization links small molecules (monomers) to create larger chain molecules (polymers), this finally develops into a fully cross-linked solid polymer.

→ Photo-polymerization is essentially the same effect, only that the catalyst introduced is light energy. The light energy kicks off a free-radical polymerization where the liquid photopolymer is phased from liquid to gel to solid.

→ The solid obtained is a Thermo-set and can be used after it had been cured (NON-Recyclable)

→ The original SLA build materials were acrylate based. Later replaced by epoxy-based materials, also known as the Acrylic Clear Epoxy System (ACES) build style.

Epoxy poses better material qualities and less hazardous but their integration requires longer exposure time for cure as well as high powered lasers

The epoxy materials provide advantages over the acrylate resins in that they have better materials properties and are less hazardous. The integration of epoxies require longer exposure time for cure as well as higher-powered lasers.

→ Resins are used to improve Resolution, Temperature capacity and even the speed of the build.

STEREO LITHOGRAPHY HARDWARE

→ The Build chamber of the SLA contains a removable vat that holds the build resin, a detachable, perforated build platen on a -Z axis elevator frame. and also an automated Resin-level checking apparatus

→ A Recoater blade rides along a track at the top of the vat, and serves to 'smooth' the liquid across the part surface to prevent rounding of edges due to cohesion effects.

→ Recoating in stereolithography apparatus (SLA) involves dipping the part being built into a vat containing liquid resin and sweeping a blade over the top of the part.

→ Some systems have zephyr recoater blade, which actually siphons up resin and delivers it evenly across the part surface.

→ The recoater System has a Zephyr recoater blade with four axes of motion. The y-axis moves the recoater blade front to rear

→ Z axis moves it up and down; theta y-axis tips or rotates the blade about the center, the x-axis motion directs sensor motion on the blade.

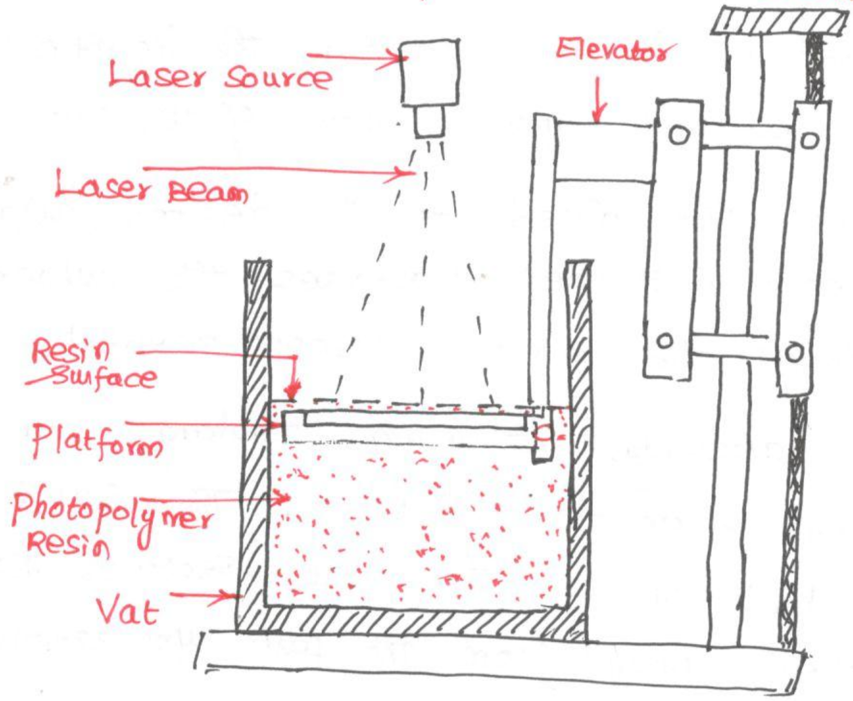
→ The recoater system's liquid level sensor maps the resin surface by moving around the resin surface. The sensor calibrates the position of the blade so that the blade moves perfectly parallel to the resin surface, enabling the build to be accuate and precise.

→ The recoating system uses the motion axes that are connected to the blade, enabling the system to self-calibrate, permitting a customized setting of the blade gap, or distance from the blade's bottom to the resin surface, for different resins.

* → In the enclosed area above and behind the build chamber, resides the laser and optics to cure the resin. The laser beam is long and rectangular, about 4 feet long, and remains stationary. The laser beam is transferred to the part surface below by a series of optics, the final of which moves to scan the cross section of the part being built.

→ post processing units like ultraviolet oven for post curing and an alcohol bath large enough to hold entire build platens with parts attached. parts are washed in the alcohol or solvent immediately after being removed from the machine. This step removes any extra resin that clings to the surfaces of the part.

STEREOLITHOGRAPHY APPARATUS OPERATION.



→ parts are built up on an elevator platform that incrementally lowers the part into the vat by the distance of the layer thickness.

→ To Build each layer, a laser beam is guided across the surface (by servo-controlled galvanometer mirrors) drawing a cross-sectional pattern in the x-y plane to form a solid section.

→ The platform is then lowered into the vat and the next layer is drawn and adhered to the previous layer. These steps are repeated, layer-by-layer, until the complete part is built up.

→ Since the photopolymers are relatively viscous, simply lowering the elevator. Through a small distance of layer thickness (~0.002 in to ~0.020 in) down in the vat does not permit the liquid to uniformly recoat the upper surface of the part in a timely fashion.

→ A Recoating mechanism is therefore required to facilitate this process. Stereo lithography uses a "deep dipping recoating", whereby the elevator is first lowered several millimetres so that the liquid entirely flows over the current upper surface of the part.

→ The elevator is then raised to the desired height and a wiper arm (Blade) traverses the surface to quickly level the excess viscous material.

→ Features with gradually changing overhangs can be built up without support structures. The supports are typically built up as thin wall sections that can easily be broken away from the part upon completion.

STRENGTHS :

→ Accuracy of +/- 0.1 mm, and surface finish are the best amongst all the processes.

→ Model building can take place unattended.

→ Capable of high detail and thin walls.

→ Good surface finish.

WEAKNESS :

* Experience and expertise is required in deciding the support structures.

* 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 self life and needs to be replaced after a period of two years.

MODULE-2: LAMINATED OBJECT MANUFACTURING.

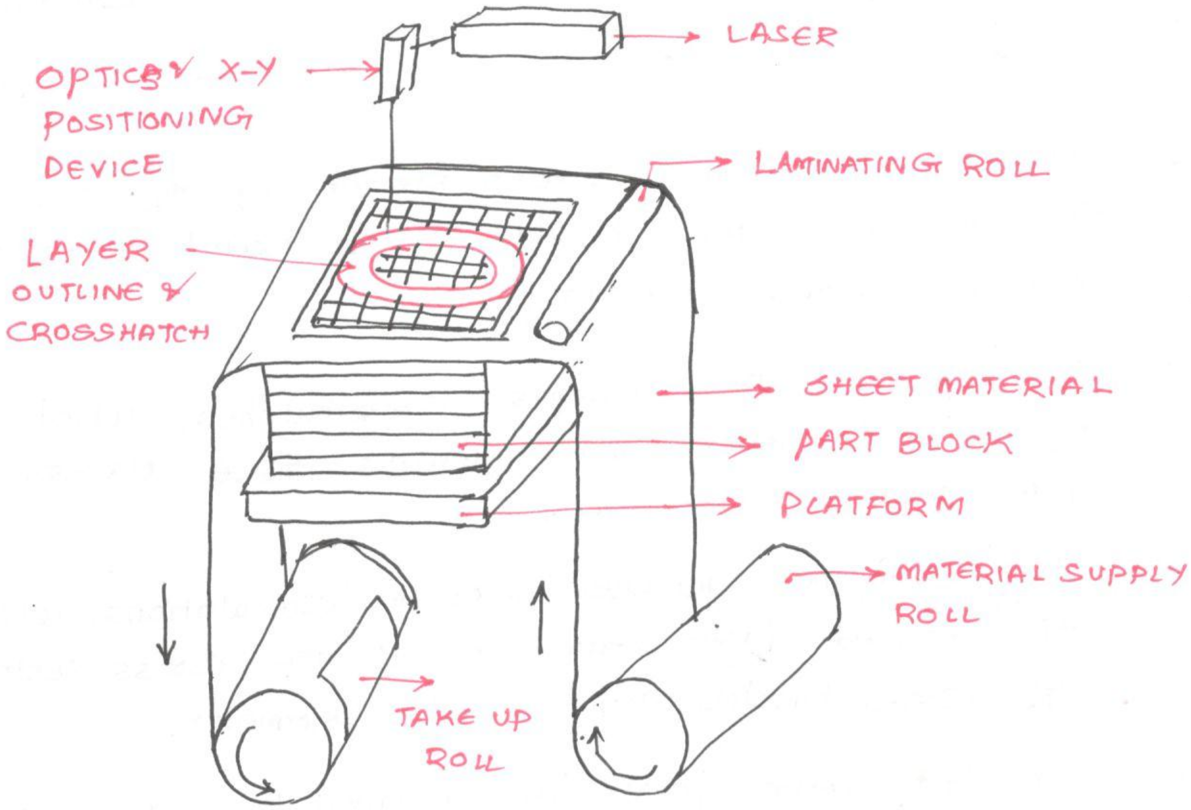
LOM: Laminated object manufacturing is a RP method that was developed and commercialized by Helisys Corporation (US).

The patented LOM process is an automated fabrication method in which a 3D object is constructed from a solid CAD representation by sequentially laminating the part cross sections.

The process consists of three phases.

(i) Preprocessing (ii) Building (iii) Post processing.

The schematic view of LOM process is shown below.

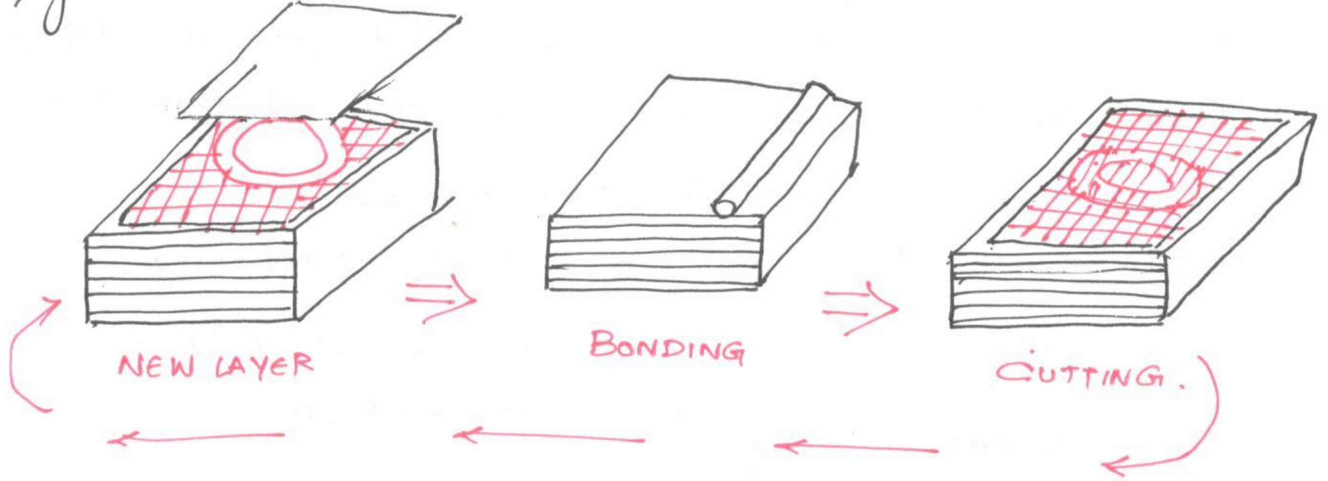


PREPROCESSING

* The pre-processing phase comprises several operations.
* The initial steps include generating an image from a CAD-derived STL file of the part to be manufactured, sorting input data and creating secondary data structures.
* Fully automated by LOM slice, the system software which calculates and controls the slicing functions.
* Orienting and merging the part on the LOM system are done manually.

BUILDING :

* In the building phase, thin layers of adhesive-coated material are sequentially bonded to each other and individually cut by a CO_2 laser beam.



1) LomSlice creates a cross section of the 3D model measuring the exact height of the model and slicing the horizontal plane accordingly.

2) The software then images crosshatches, which defines the outer perimeter and converts these excess materials into support structure.

3) The computer generates precise calculations, which guides the focused laser beam to cut the cross-sectional outline, the cross hatches and model's perimeter.

4) The laser beam power is designed to cut exactly the thickness of one layer of material at a time. After the perimeter is burned, everything within the model's boundary is freed from the remaining sheet.

5) The platform with the stack of previously formed layer descends and a new section of material advances. The platform ascends and the heated roller laminates the material to the stack with a single reciprocal motion, thereby bonding it to the previous layer.

6) The vertical encoder measures the height of the stack and relays the new height to LOM Slice, which calculates the cross-section for the next layer as the laser cuts the model's current layer.

7) This sequence continues until all the layers are built. The product emerges from the LOM Machine as a completely enclosed rectangular block containing the part.

POST PROCESSING :

The last phase, post processing includes separating the part from its support material and finishing it. The separation sequence is as follows.

1) The metal platform from the newly created part is removed from the LOM machine. A forklift may be needed to remove the larger and heavier parts.

2) Normally a hammer and a knife is required to separate the LOM block from the platform. However, a live thin wire may also be used to slice through the double-sided foam tape which serves as a connecting point between the LOM stack and the platform.

3) The surrounding wall frame is lifted off the block to expose the cross hatched pieces of the excess material. Cross hatched pieces may then be separated from the part using wood carving tools.

4) After the part has been separated, it is recommended that it be sealed immediately with urethane, epoxy, or silicon spray to prevent moisture absorption and expansion of the part.

5) Lom parts can also be machined using conventional machines like those for drilling, milling and Turning.

@ → Lom Builds shapes with layers of paper or plastic. The laminates, which have a thermally actuated adhesive, are glued to the previous layer with a heated roller.

→ A laser cuts the outline of the part cross-section for each layer.

→ The laser then scribes the remaining material in each layer into a cross hatch pattern of small squares, and as the process repeats, the cross hatches build up into tiles of support structure.

→ The Cross hatching facilitates removal of this structure when the part is completed.

Lom builds up large parts relatively rapidly because only contours are scanned.

→ Internal cavities are hard to form with Lom, Since it is difficult to remove the Sacrificial material from the internal regions.

~~STRENGTHS~~:

→ Lamination is accomplished by applying heat and pressure by the way of rolling a heated cylinder across the sheet of material that has a thin layer of a thermoplastic adhesive on the one side.

→ Studies have indicated that the interlaminate strength of Lom parts is a function of bonding speed, sheet deformation, roller temperature and contact area between the paper and the roller.

→ By increasing pressure of the heated roller, lamination is improved with fewer air bubbles.

→ Increased pressure also augments the contact area and bolster interlaminate strength. pressure is controlled by the limit switch mounted on the heated roller.

→ Too high a compression can cause distortion in the part.

The Material supply and Take up System comprises two material roll supports (supply and Rewind), several idle rollers to direct the material and two rubber-coated nip rollers (Driving and idle), which advance or rewind the sheet material during the preprocessing and building phases.

To make material flow through the LOM systems more smoothly, mechanical nip rollers are used. The friction resulting from compressing moving material between rubber-coated rollers on both the feed and wind mechanism ensures a clean feed and avoids Jamming.

MATERIALS :

Plastics, Metals and even Ceramic tapes can be used. Most popular material has been kraft paper with a Polyethylene-based heat seal adhesive system because it is widely available, cost-effective and environmentally benign.

STRENGTHS :

a) Only the outline is cut. Therefore, no time is spent in building the body of the layer.

b) The materials used for building the parts (wood and paper) are the least expensive amongst all RP process.

c) Cost of the machine is one of the lowest
d) No support structures or post curing is required
e) It is suitable and economical for making large parts to be used as patterns for sand castings
f) The process can be carried out unattended.

WEAKNESSES :

a) parts have poor surface finish and absorb moisture.
b) parts ~~have poo~~ is not suitable for making small intricate parts. As the parts need to be chipped out from a wooden box, after they are built, a lot of skill is required if parts with intricate details needs to be chipped out.
c) Parts are weak in Z-direction
d) There is a lot of material wastage.

MODULE - 2 :

SELECTIVE LASER SINTERING :

The Selective Laser Sintering (SLS) process was developed by the University of Texas in Austin, and was commercialized by DTM, Corporation in 1987. The first commercially available system was introduced by DTM in 1992. The latest SLS system by DTM is the Sinter Station 2500 plus with build chamber dimensions of 381 mm in width, 330 mm in depth and 457 mm in height.

SELECTIVE LASER SINTERING TECHNOLOGY [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-di-oxide laser to form the final product. SLS has 10 different build materials that can be used within the same machine for a wide variety of applications.

→ At present, Nylon (polyamides), Nylon composites, polystyrene and polycarbonate are in use. These are cheaper, Non-toxic safe and may be sintered with relatively low-power lasers (10-20 W)

→ Two Nylon-based materials are available commercially for the SLS process. (Dura form polyamide, & Dura form Glass filled). Typically, The Nylon based materials are used for the production of prototypes for testing or parts with relatively easily finished to a smooth appearance

→ The production of Nylon parts is generally cost effective when a small number of parts is required.

→ Another group of SLS materials is used for producing casting patterns. Currently two materials, Trueform and Castform are employed for building patterns.

→ Trueform, an acrylic-based powder, is processed at relatively low temperatures compared with Nylon which limits shrinkage to 0.6% and is for making parts with good accuracy but moderate strength.

→ The density of Trueform parts can vary from 70-90% depending on build parameters and they can be polished to a mirror-like finish.

→ Castform, a polystyrene-based powder, was introduced by DTM in 1999. This new material offers significant advantages over Trueform when employed to produce patterns for investment casting. In particular, it features a low ash content and is compatible with standard foundry practices.

→ Processing Castform creates porous low density patterns that are subsequently infiltrated with a low-ash foundry wax to yield patterns containing 45% polystyrene and 55% wax.

→ Nylon parts need a long cooling cycle in the machine before they can be removed. For example, Nylon composite parts require 6-8 hours to cool down. The materials employed by the system are sensitive to the different heating and laser parameters and each material requires distinct settings.

DURAFORM EX PLASTIC :

* These are impact - Resistant plastic offering the Toughness of injection - molded Thermoplastics and

are suitable for rapid manufacturing. They are available in either Natural (white) or black colours.

→ Features of the materials are as follows:

a) It offers the Toughness and impact resistance of injection - molded ABS and polypropylene.

b) Applications for the material include complex, thin walled ductwork, motor sports, aerospace and unmanned air vehicles (UAV's), Snap-fit designs, hinges, vehicle dashboards, grilles and Bumpers.

DURAFORM FLEX PLASTIC :

→ This is a thermoplastic elastomer material with rubber-like flexibility and functionality

→ features of the material are as follows.

* Flexible, durable with good Tear resistance, Variability of hardness using the same material, good powder recycle characteristics, good surface finish and feature detail.

* The application for the material includes athletic foot wear and equipment, gaskets, hoses and seals simulated thermoplastic elastomer, cast urethane, silicone and rubber parts.

DURAFORM AF PLASTIC :

→ These are polyamide (Nylon) material with metallic appearance for real world physical testing and functional use.

→ features are : Metallic appearance with nice surface finish, good powder recycle characteristics, excellent mechanical stiffness, easy to process and dimensional stability.

Applications for the material includes

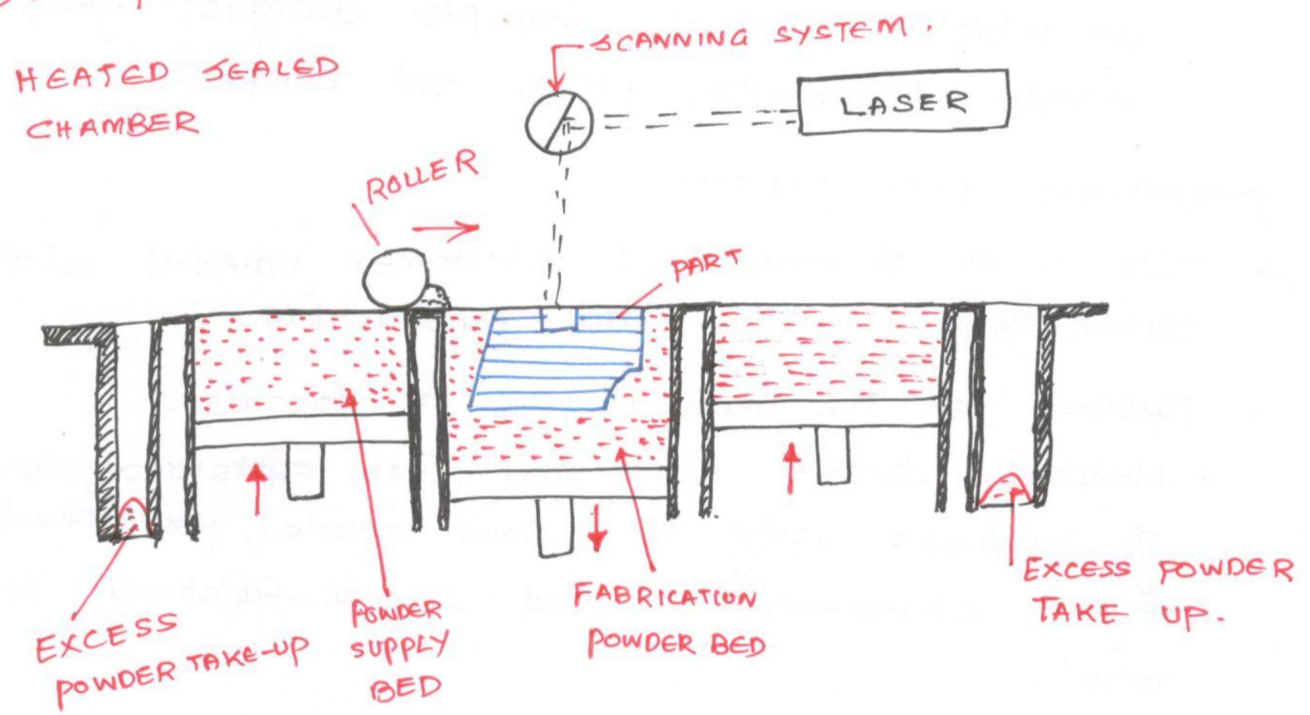
→ housings and enclosures

→ Consumer products

→ Thermally stressed parts

→ plastic parts requiring metallic appearance.

SLS PROCESS :



→ The SLS process creates 3D objects, layer by layer, from CAD data using powdered materials with heat generated by a CO_2 laser within the Sinterstation.

→ CAD files in the .STL file format are first transferred to the Sinterstation system where they are sliced.

→ The operation of SLS are as follows.

a) A Thin layer of heat-fusible powder is deposited onto the part building chamber.

b) * The Bottom-most cross-sectional slice of the CAD
part to be fabricated is selectively 'drawn' (or
scanned) on the layer of powder by CO_2 laser.

* The interaction of laser beam with the powder
elevates the temperature to the point of melting,
fusing the powder particles to form a solid mass.

*. The intensity of laser beam is modulated to melt
the powder only in areas defined by the part's
geometry. Surrounding powder remains a loose
compact and serves as natural supports.

c) When the cross section is completely drawn an
additional layer of powder is deposited via a
roller mechanism on top of the previously scanned
layer. This prepares the next layer for scanning.

d) Step 'b' and 'c' are repeated, with each layer
fusing to the layer below it. Successive layers
of powder are deposited and the process is
repeated until the part is complete.

* As SLS materials are in powdered form, the
powder not melted or fused during processing
serves as a customized, inherent built in support
structure. Thus, there is no need to create additional
support structures within the CAD design and
therefore no post-build removal of these supports are
needed.

* After the SLS process, the part is removed from
the build chamber and the loose powder simply

falls away.

* SLS parts may then require some post-processing or secondary finishing such as sanding, lacquering and painting depending upon the application of the prototype built.

The Sinter station PRO SLS system contains hardware components as follows:

1) Sinterstation PRO SLS System: Manufactures parts from 3D CAD data.

2) Rapid change module (RCM): Build module mounted on wheels for quick and easy transfer between the Sinterstation, the offline Thermal Station (OTS) and the Break-out station (BOS)

3) Nitrogen generator :- Delivers a continuous supply of Nitrogen to the SLS System to keep the fabrication inert and prevents oxidation.

4) Offline Thermal Station (OTS): Preheats the Rapid change module before it is loaded into the system and controls the RCM cool-down process after a build has been completed.

5) Break-out station :- The Built parts are extracted from the powder cake here. The non sintered powder automatically gets shifted and transferred to the integrated recycling station (IRS)

6) Integrated Recycling Station: (IRS): The IRS automatically blends recycled and new powder. The mixed powder is automatically transferred to the SLS system.

7) Intelligent powder Catridge (IPC) : New powder is loaded into the IRS from a returnable powder catridge. When the IPC is connected to the IRS, electronic material information is automatically transferred to the SLS system.

The software that comes with Sinterstation PRO SLS system includes the following.

→ Build set-up and sinter (included)

→ Sinterscan (optional) software provides more uniform properties in X and y directions and improved surface finish.

→ Real monitor (optional) software provides advanced monitoring and tracking capabilities.

The SLS process is based on following two principles

(I). Parts are built by sintering when a CO_2 laser beam hit a thin layer of powdered material. The interaction of the laser beam with the powder raises the temperature of the powder to the point of melting, resulting in particle bonding, fusing the particles to themselves and the previous layer to form a solid. This forms the basic principle of sinter bonding.

(II). The building of the part is done layer by layer. Each layer of the building process contains the cross section of one or many parts. The next layer is then built directly on top of sintered layer after an additional layer of powder is deposited via a roller mechanism.

→ The packing density of particles during sintering affects the part density. particles packing with uniform-sized particles, packing densities are found to range typically from 50%. to 62%.

→ Higher the packing density, the better will be the expected mechanical properties.

→ However, Scan pattern and exposure parameters are also major factors in determining the part's mechanical properties.

SINTER BONDING :

* Particles in each successive layer are fused to each other and to the previous layer by raising their temperature with the laser beam above the glass-transition temperature.
* The glass transition temperature is the temperature at which the material begins to soften from a solid state to a Jelly like condition.
* This often occurs just prior to the melting temperature at which the material will be in a molten or liquid state.
* As a result, the particles begins to soften and deform owing to its weight and cause the surfaces in contact with other particles or solid to deform and fuse together at these contact surfaces.
* One major advantage of sintering over melting and fusing is that it joins powder particles into a solid part without going into the liquid phase, thus avoiding the distortions caused by flow of molten material during fusing

After cooling, the powder particles are connected in a matrix that has approximately the density of the particle material.

* As the sintering process requires the machine to bring the temperature of the particles to glass transition temperature the energy required is considerable. The energy required to sinter is approximately between 300 and 500 times higher than that required for photo-polymerization.
* The high power requirement can be reduced by using auxiliary heaters to raise the powder temperature to just below the sintering temperature during the sintering process.
* Inert gas ~~requi~~ environment is needed to prevent oxidation or explosion of the fine powder particles. Cooling is also necessary for the chamber gas.

STRENGTHS OF SELECTIVE LASER SINTERING :

The strengths includes :

1) Good part stability : parts are created within a precise controlled environment.
2) Wide range of processing materials : A wide range of materials includes Nylon, polycarbonates, metals and ceramics are available directly from 3D systems, thus providing flexibility and wide scope of functional applications.
3) No part supports Required : The system do not require CAD-developed support structures. This saves the time required for support structure building and removal.
4) Little post processing required : The finish is reasonably fine and requires little post processing such as particle blasting and sand blasting.

5) NO post-curing required: The laser sintered part is generally solid enough and does not require further curing.

6) Advanced Software Support: Newer version of windows with Graphical User Inteface is used. It allows for, Streamlined parts scaling, advanced non-linear parts scaling in-progress part changes, build report utilities and is available in foriegn languages.

WEAKNESSES OF SELECTIVE LASER SINTERING

1) Large physical size of the unit: System requires a relatively large space to house it. Also, additional storage space is required to house the inert gas tanks that are required for each build.

2) High power Consumption: System requires high power Consumption due to the high wattage of the laser required to sinter the powder particles together.

3) Poor Surface finish: The as-produced parts tends to have poorer Surface finish due to the relatively large particle sizes of the powders used.

UNDER STRENGTHS OF SLS SYSTEM:

→ Scanning Speed: The Scanning speed is essentially the velocity of laser movement across the part surface while it fuses the build material together. Since the systems are equipped with a powerful 50 Watt Carbon-di-oxide ~~laser~~ laser, the scanning speed is very fast so that large part cross sections can be scanned in seconds. This high rate allows for Multiple parts to be built in a short turnaround time.

APPLICATIONS :

The applications includes the following

1) Concept Models : Physical representations of designs used to review design ideas, form and style.

2) Functional modes and working prototypes : parts that can withstand limited functional testing, or fit and operate within an assembly.

3) Polycarbonate (Rapid Casting) patterns : patterns produced using Polycarbonate and then cast in the metal of choice through the standard investment Casting process. These build faster than the wax patterns, and are suited for designs with thin walls and fine features.

4) Metal Tools : Direct rapid prototype of tools of molds for small or short production runs.

SOLID GROUND CURING [SGC]

→ SGC systems were developed by cubital Ltd. cubital was founded in 1987 as an internal R & D unit and the first SGC system was installed in 1991.

→ SGC is a Resin based Rapid prototyping process manufactured by CUBITAL in Israel. The process employs a photosensitive resin similar to stereolithography, in addition to a variety of other integrated subsystems to fabricate prototypes.

PRINCIPLE OF SOLID GROUND CURING:

→ Cubital's RP technology creates highly physical models directly from Computerized 3D data files. parts of any geometric complexity can be produced without tools, dies or Molds by CUBITAL's RP Technology.

The process is based on following principles.

a) Parts are built, layer by layer, from a liquid photo-polymer resin that solidifies when exposed to UV light. In this photo-polymerization process irradiation source is high power collimated UV lamp and the image of the layer is generated by masked illumination instead of optical scanning of a laser beam.

The mask is created from the CAD data input and 'printed' on a transparent substrate (the mask plate) by a non-impact ionographic printing process, a process similar to the xerography process used in photo-copier and laser printers.

The image is formed by depositing black powder, a toner which adheres to the substrate electrostatically. This is used to mask the uniform illumination of UV lamp.

After exposure, the electrostatic toner is removed from the substrate for reuse and the pattern for the next layer is similarly 'printed' on the substrate.

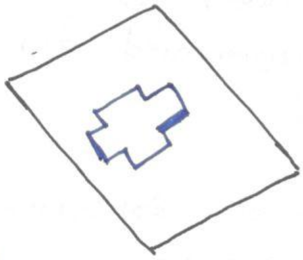
(b) Multiple parts may be processed and built in parallel by grouping them into batches (runs) using Cubital's Proprietary software.

c) Each layer of a multiple layer run contains cross sectional slices of one or many parts. Therefore all slices in one layer are created simultaneously. Layers are created thicker than desired. This is to allow the layer to be milled precisely to its exact thickness, thus giving overall control of vertical accuracy.
This step produces a roughened surface of cured photopolymer assisting adhesion of the next layer to it. The next layer is then built immediately on the top of the created layer.

d) The process is self-supporting and does not require the addition of external support structures to emerging parts since continuous structural support for the parts is provided by the use of wax, acting as a solid support material.

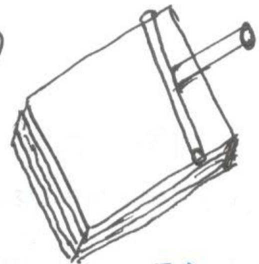
SOLID GROUND CURING PROCESS

1)



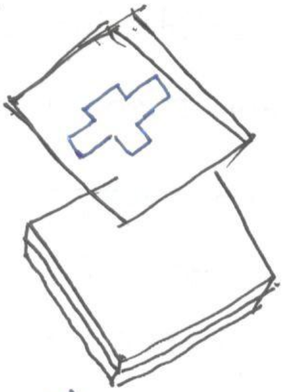
a) The image of the layer is produced using Toner on a glass plate, to create a photomask.

2)



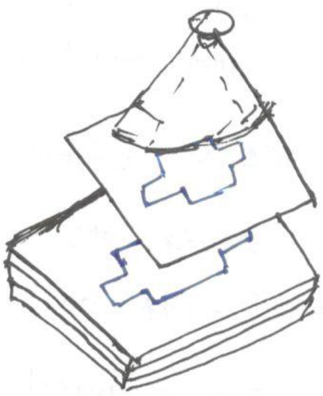
b) A Thin resin layer is applied on a flat workpiece.

3)



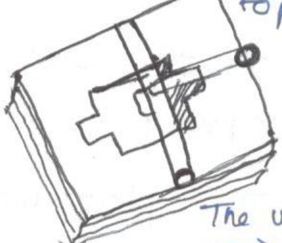
c) photomask is placed above the workpiece and both are alyned under a collimated UV lamp.

4)



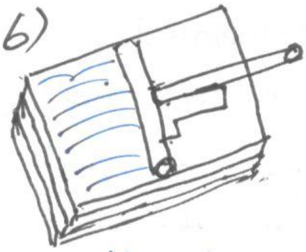
UV light is Turned on for few seconds. Part of resin layer is hardened according to photomask.

5)



The unsolidified resin is removed from workpiece

6)

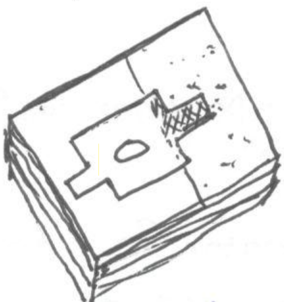


Melted Wax is spread unto the cavities created and hardened.

7)

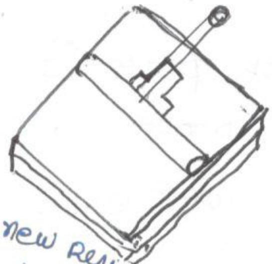
The layer is milled to achieve a smooth and precise layer height.

8)



The workpiece travels under a powerful longitudinal UV lamp for final curing of the layer

9)



A new Resin layer is applied on the workpiece.

The Solid Ground curing Comprises three main steps.
a) Data preparation b) Mask Generation c) Model making.

a) Data preparation:

* In this first step, the CAD model is prepared and the cross sections are ~~generally~~ generated digitally and transferred to the mask generator.

* The software used, Data front end software, is a CAD application package that processes data prior to sending them to the cubital system.

* DFE can search and correct flaws in the CAD files and render files on-screen for visualization purposes.

b) MASK GENERATION:

* After the data are received, the mask plate is charged through an "image wise" ionographic process (Item 1)

* The charged image is then developed with electrostatic Toner.

c) MODEL MAKING:

* In this step, a thin layer of photo-polymer resin is spread on the work surface (Item 2)

* The photo mask from the mask generator is placed in close proximity above the work piece and alyned under a collumated UV lamp (Item 3). The UV light is turned on for a few seconds (Item 4)

* The part of resin layer which is exposed to the UV light through the photo mask is hardened. The layers laid down for exposure to the lamp are actually thicker than the desired thickness. This is to allow for the final milling process.

* The unsolidified resin is then collected from the work piece (Item 5) by vacuum suction. Melted wax is then spread into the cavities (Item 6)
* Consequently, the wax in the cavities is cooled to produce a wholly solid layer. The layer is then milled to its exact thickness, producing a flat surface ready to receive the next layer. (Item 7)
* Additional step (Item 8) is provided for final curing of the layer whereby the workpiece travels under a powerful longitudinal UV lamp.
* The cycle repeats itself until the final layer is completed

CUBITAL INC's SOLDER :

Irradiation medium → High power UV lamp

XY resolution (mm) → Better than 0.1

Surface definition (mm) → 0.15.

Elevator vertical resolution (mm) → 0.1 – 0.2

Minimum feature size (mm) → 0.4 (horizontal, X – Y)
0.15 (vertical Z)
– 0.4 (horizontal X – Y)

Work Volume, XYZ (mm×mm×mm) → 350 × 350 × 350 – 500 × 350 × 500

production rate (cm³/h) → 550 – 1,311

Minimum layer thickness (mm) → 0.06

Dimensional accuracy → 0.1 %.

Size of unit, XYZ (m×m×m) → 1.8 × 4.2 × 2.9 – 1.8 × 4.2 × 2.9

Data control unit → Data front end (DFE) workstation.

STRENGTHS

1) Build-time is independent of the number of parts being made at a Time. Therefore it can act as a production machine.

2) No external ~~supports~~ structures are required.

3) No warping or curling of the part takes place, as there is no post curing operation.

4) Large variety of photopolymers can be used for building the parts.

5) Accuracy of parts is good.

WEAKNESSES

1) There is a lot of wastage of material and wax. The resin picked up by the aerodynamic wiper and vacuum during the milling process cannot be used again. Additionally, the material which does not form the part of the model, but gets exposed to the UV light needs to be ~~replaced~~. replaced. Only fifty percent of this affected material can be converted into usable form.

2) The cost of the machine is highest amongst all RP machines.

3) The process operation is complex and maintenance cost is high.

4) Monitoring of the building process is required.

5) Wax is sticky and difficult to remove.

FUSED DEPOSITION MODELING :

→ Fused Deposition modeling (FDM) is an extrusion-based Rapid Prototyping process, although it works on the same layer-by-layer principle as other RP systems.

→ Extruding freeform shapes was first developed and commercialized by Stratasys Inc (US).

FUSED DEPOSITION MODELING SYSTEM HARDWARE :

→ FDM have evolved through several models, beginning with 3D modeler, a floor unit and progressing through the various desktop units.

→ Stratasys has released the FDM system, which has a unique water soluble support (WSS) material. The WSS material allows for the construction of more complex geometry and internal structures.

FDM SOFTWARE :

→ FDM uses the powerful Quickslice (QS) software, developed by Stratasys to manipulate and prepare the incoming STL data for use in FDM machines.

→ The software can be operated on various types of workstations, from UNIX to PC based and the modelers can be operated directly from the workstation.

BUILD MATERIALS :

→ The FDM can be equipped to build with investment casting wax, acrylonitrile butadiene styrene (ABS) plastic, medical grade ABS, thermoplastic.

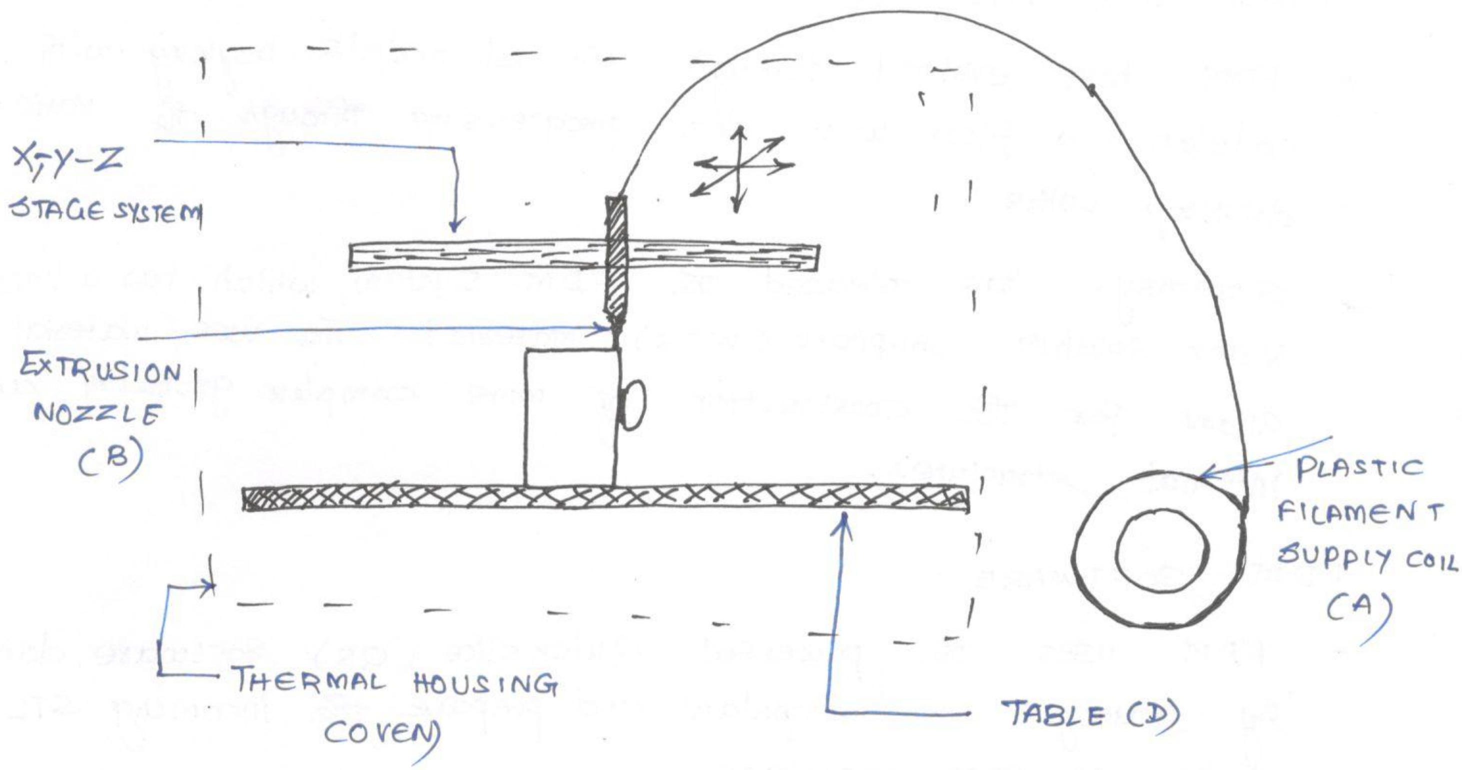
→ The build and support materials come in filament form, about 0.070" in diameter and rolled up on spools.

THE EXTRUSION HEAD :

→ The extrusion head is the key to FDM technology.

→ The head is a compact, removable unit (good for materials changeover and maintenance).

→ The Schematic View of Fused deposition Modeling is shown in the figure below.



→ A plastic filament, approximately 1/16 inch in diameter, is unwound from a coil (A) and supplies material to an extrusion Nozzle (B).

→ Some Configurations of the machinery have used plastic pellets fed from a hopper rather than a filament. The Nozzle is heated to melt the plastic and has a mechanism which allows the flow of melted plastic to be controlled.

→ The Nozzle is mounted to a mechanical stage (c) which can be moved in horizontal and vertical directions.

→ As the Nozzle is moved over the table (D) in the required geometry, it deposits a thin bead of extruded plastic to form each layer.

→ The plastic hardens immediately after being squirted from the Nozzle and bonds to the layer below.

→ The entire system is contained within an oven chamber which is held at a temperature just below the melting point of the plastic.

→ Thus, only a small amount of additional thermal energy needs to be supplied by the extrusion Nozzle to cause the plastic to melt. This provides much better control of the process.

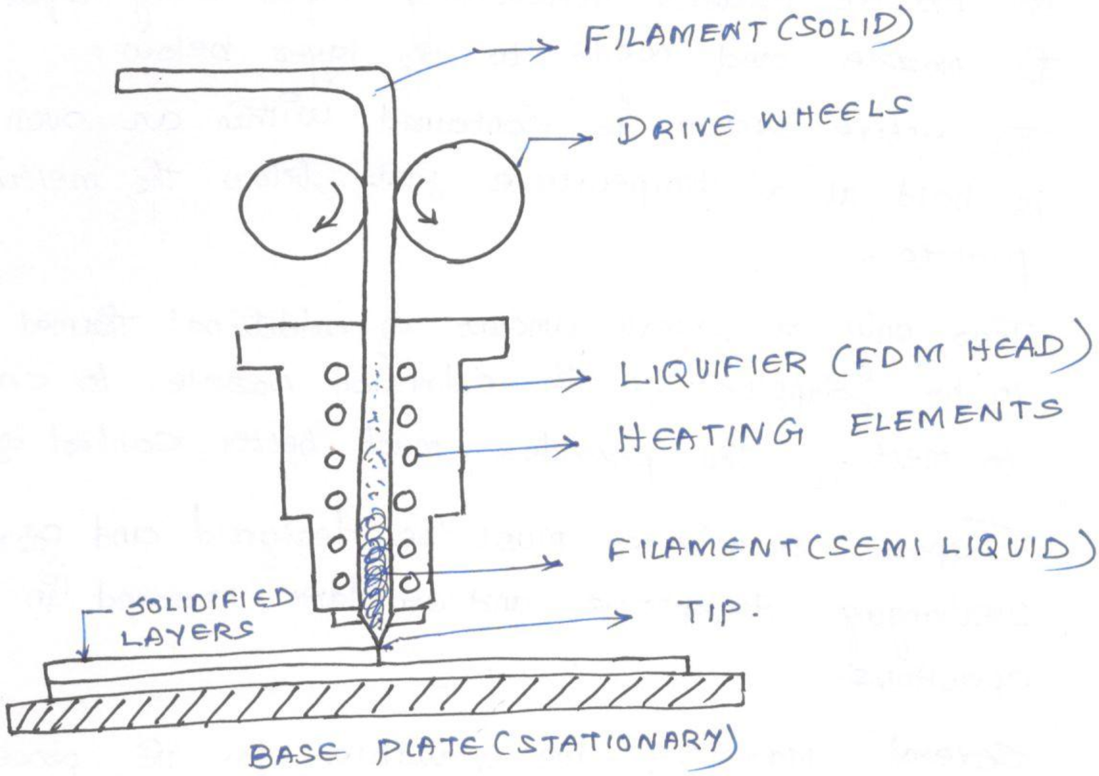
→ Support structures must be designed and fabricated for any overhanging geometries and are later removed in secondary operations.

Several materials are available for the process including a nylon-like polymer both machinable and investment casting waxes.

→ The introduction of ABS plastic material led to much greater commercial acceptance of the method. It provides better layer to layer bonding and much more robust fabricated objects.

Water soluble support materials have also become available which can be removed simply by washing them away. The recent introduction of polycarbonate and poly (phenyl) sulphone modeling materials have further extended the capabilities of the method in terms of strength and temperature range.

→ Parameters that affects the performance and functionalities of the system are Material column strength, Material flexural modulus, Material viscosity, positioning accuracy, widths, deposition speed, volumetric flow rate, tip diameter, envelope temperature and part geometry.



→ A Geometric model of a Conceptual design is created on CAD Software, which uses .STL or IGES formatted files.

→ It is imported into the workstation where it is processed through the 'Insight' Software for the Dimension series, which automatically generates the supports.

→ within this software, the CAD file is sliced into horizontal layers after the part is oriented for the optimum build position and any necessary support structures are automatically detected and generated.

→ The slice thickness can be set manually anywhere between 0.178 and 0.356 mm (0.007 and 0.014 in), depending on the needs of the model.

→ Tool paths of the build process are then generated, which are downloaded to the FDM machine.

STRENGTHS OF FDM :

→ The machine is less expensive.
→ Variety of materials can be used and the material changeover, which involves only changing the head, is very fast and simple.
→ No post-curing is required.
→ There is a little wastage of material.
→ The part building can be carried out unattended. The material has a large shelf life and remains unaffected if not removed from the packing provided.

WEAKNESSES OF FDM :

→ Surface finish and delicate features are inferior to other processes.
→ process is slow on bulky parts.
→ Strength is low in vertical direction.
→ Accuracy and surface finish is less as compared to other RP processes.

APPLICATIONS :

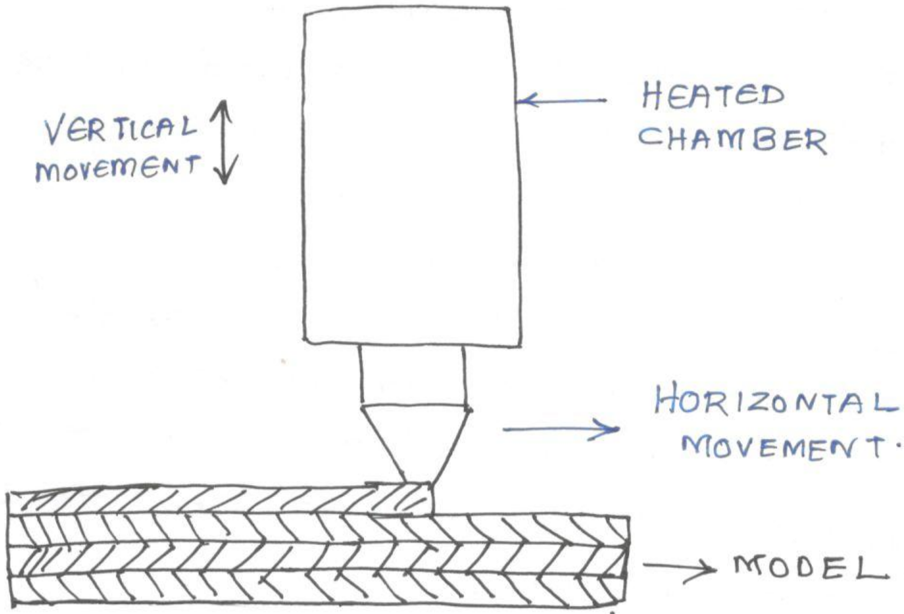
a) Models for conceptualization and presentation.
b) prototypes for design, analysis and functional testing
c) patterns and masters for tooling.

SIMILAR PROCESSES.

→ Multiphase Jet Solidification (MJS) is another extrusion base process being jointly developed by the Fraunhofer Institute of applied materials Research (IFAM, Bremen) and manufacturing Engineering and Automation (IPA, Stuttgart)

→ MJS extrudes metal ceramic slurries using metal injection Molding Technology. The slurry which is about 50/50 mixture of wax and metal or ceramic powder is contained in a heated vessel and pumped through an attached nozzle with a screw actuated plunger.

SCHEMATIC VIEW OF MJS :-



→ The main components of the apparatus used for MJS process comprises a PC, a Computer Controlled three axes positioning system and a heated chamber with a jet and a hauling system.

→ The machine precision of the positioning system is ±0.01mm and has a work volume of 500 X 540 X175 mm. The chamber is temperature stabilized within ±1°c.

→ The material is supplied as powder, pellets or bars. Extrusion temperature can reach upto 200°c. Extrusion orifice vary from 0.5 to 2 mm.

→ In MJS system, parameters that influence its performance and functionality are the layer thickness, the feed material (i.e) whether it is liquefied alloys (using low-melting point metals) or powder-binder mixture (usually materials with high melting point), chamber pressure, the machining speed (build speed), jet specification, material flow and operating Temperature.