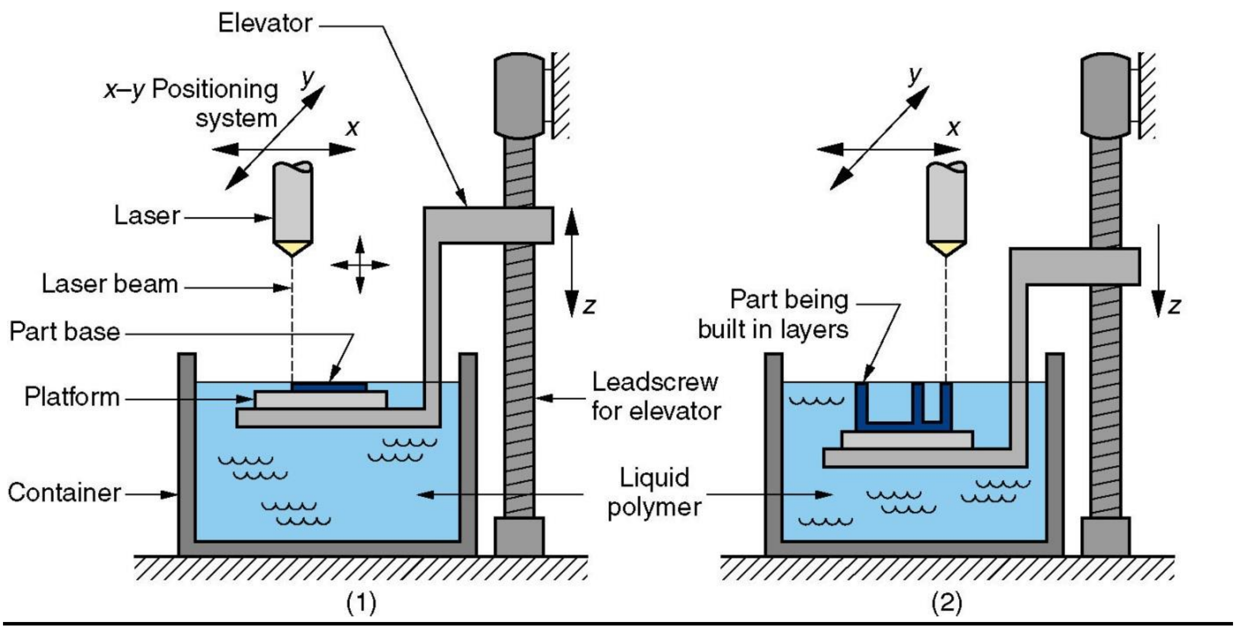
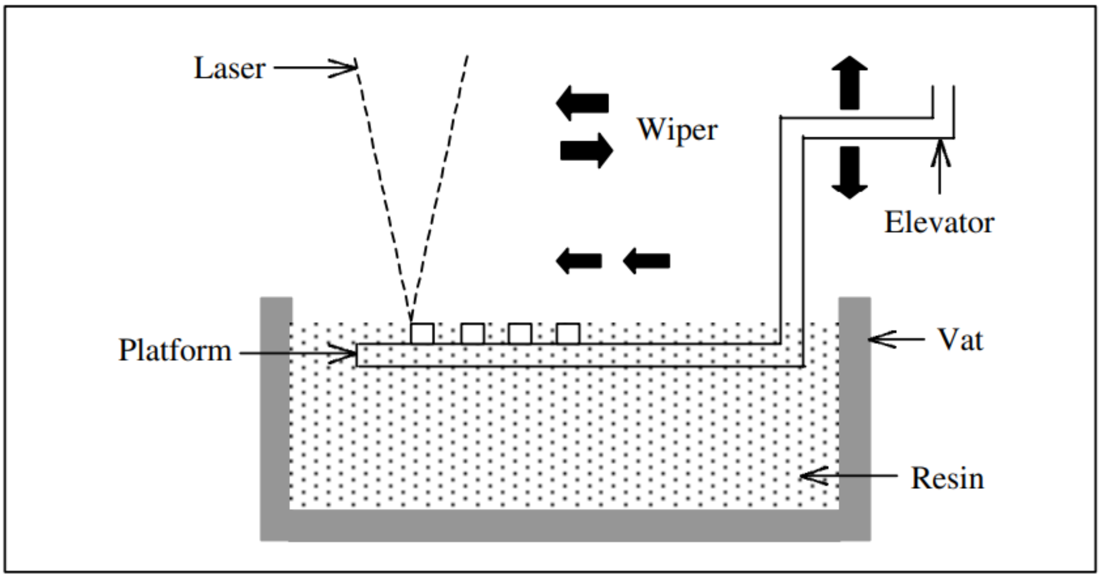
AMT--- UNIT 2 LIQUID BASED TECHNOLOGY

Stereolithography Working Principle.



Stereolithography: (1) at the start of the process, in which the initial layer is added to the platform; and (2) after several layers have been added so that the part geometry gradually takes form.



Schematic of SLA process

Layering Technology, Laser and Laser Scanning

Almost all RP systems use layering technology in the creation of prototype parts. The basic principle is the availability of computer software to slice a CAD model into layers and reproduce it in an "output" device like a laser scanning system. The layer thickness is controlled by a precision elevation mechanism. It will correspond directly to the slice thickness of the computer model and the cured thickness of the resin. The limiting aspect of the RP system tends to be the curing thickness rather than the resolution of the elevation mechanism. The important component of the building process is the laser and its optical scanning system. The key to the strength of the SLA is its ability to rapidly direct focused radiation of appropriate power and wavelength onto the surface of the liquid photopolymer resin, forming patterns of solidified photopolymer according to the cross-sectional data generated by the computer. In the SLA, a laser beam with a specified power and wavelength is sent through a beam expanding telescope to fill the optical aperture of a pair of cross axis, galvanometer driven, and beam scanning mirrors. These form the optical scanning system of the SLA. The beam comes to a focus on the surface of a liquid photopolymer, curing a predetermined depth of the resin after a controlled time of exposure (inversely proportional to the laser scanning speed). The solidification of the liquid resin depends on the energy per unit area (or "exposure") deposited during the motion of the focused spot on the surface of the photopolymer. There is a threshold exposure that must be exceeded for the photopolymer to solidify.

To maintain accuracy and consistency during part building using the SLA, the cure depth and the cured line width must be controlled. As such, accurate exposure and focused spot size become essential. Parameters which influence performance and functionality of the parts are the physical and chemical properties of the resin, the speed and resolution of the optical scanning system, the power, wavelength and type of the laser used, the spot size of the laser, the recoating system, and the post-curing process.

Lasers are the most effective energy source in Additive Manufacturing since the laser beam can transfer a large amount of energy into micro scale focal region instantaneously to solidify or cure materialsin air.

Therefore enabling high precision, high through put manufacturing for a wide range of materials.

Laser scanners are non contact devices that capture millions of discrete data points to measure an object or space using laser infra red technology that produces the detailed 3D images in minutes.

CUBITAL'S SOLID GROUND CURING (SGC)

The Solid Ground Curing (SGC) System is produced by Cubital Ltd. and its address is Cubital Ltd., 13 Hasadna St., P.O.B. 2375, Industrial Zone North Raanana, 43650 Israel. Outside Israel, Cubital America Inc. is located at 1307F Allen Drive Troy, MI 48083, USA and Cubital GmbH, at Ringstrasse 132 55543

Bad-Kreuznach, Germany. Cubital Ltd.'s operations began in 1987 as a spin-off from Scitex Corporation and commercial sales began in 1991.

Models and Specifications

Cubital's products include the Solider 4600 and Solider 5600. The Solider 4600 is Cubital's entry level three-dimensional model making system based on Solid Ground Curing. The Solider 5600, Cubital's sophisticated high-end system, provides a wider range and options for the varied modeling demands of Solid Ground Curing. Table below Summarizes the specifications of the two machines.

Cubital's system uses several kinds of resins, including liquid resin and cured resin as materials to create parts, water soluble wax as support material and ionographic solid toner for creating an erasable image of the cross-section on a glass mask.

Model	Solider 4600	Solider 5600
Irradiation medium	High power UV lamp	
XY resolution (mm)	Better than 0.1	
Surface definition (mm)	0.15	0.15
Elevator vertical resolution (mm)	0.15	0.1–0.2
Minimum feature size (mm)	0.4 (horizontal, *X–Y*) 0.15 (vertical, *Z*)	0.4 (horizontal, *X–Y*) 0.15 (vertical, *Z*)
Work volume, *XYZ* (mm × mm × mm)	350 × 350 × 350	500 × 350 × 500
Production rate (cm^3/hr)	550	1311
Minimum layer thickness (mm)	0.06	0.06
Dimensional accuracy	0.1%	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	
Power supply	380–415 V_{AC}, 3 phase, 50 kW	380–415 V_{AC}, 3 phase, 50 kW

Advantages and Disadvantages

The Solider system has the following advantages:

(1) Parallel processing. The process is based on instant, simultaneous curing of a whole cross-sectional layer area (rather than point-bypoint curing). It has a high speed throughput that is about eight

times faster than its competitors. Its production costs can be 25% to 50% lower. It is a time and cost saving process.

(2) Self-supporting. It is user-friendly, fast, and simple to use. It has a solid modeling environment with unlimited geometry. The solid wax supports the part in all dimensions and therefore a support structure is not required.

(3) Fault tolerance. It has good fault tolerances. Removable trays allow job changing during a run and layers are erasable.

(4) Unique part properties. The part that the Solider system produces is reliable, accurate, sturdy, machinable, and can be mechanically finished.

(5) CAD to RP software. Cubital's RP software, Data Front End (DFE), processes solid model CAD files before they are transferred to the Cubital's machines. The DFE is an interactive and user friendly software.

(6) Minimum shrinkage effect. This is due to the full curing of every layer.

(7) High structural strength and stability. This is due to the curing process that minimizes the development of internal stresses in the structure. As a result, they are much less brittle.

(8) No hazardous odors are generated. The resin stays in a liquid state for a very short time, and the uncured liquid is wiped off immediately. Thus safety is considerably higher.

The Solider system has the following disadvantages:

(1) Requires large physical space. The size of the system is much larger than other systems with a similar build volume size.
(2) Wax gets stuck in corners and crevices. It is difficult to remove wax from parts with intricate geometry. Thus, some wax may be left behind.
(3) Waste material produced. The milling process creates shavings, which have to be cleaned from the machine.
(4) Noisy. The Solider system generates a high level of noise as compared to other systems.

SGC Process:-

The Cubital's Solid Ground Curing process includes three main steps: data preparation, mask generation and model making.

1. Data Preparation

In this first step, the CAD model of the job to be prototyped is prepared and the cross-sections are generated digitally and transferred to the mask generator. The software used, Cubital's Solider DFE (Data Front End) software, is a motif-based special-purpose CAD application package that processes solid model CAD files prior to sending them to Cubital Solider system. DFE can search and correct flaws in the CAD files and render files on-screen for visualization purposes. Solider DFE accepts CAD files in the STL format and other widely used formats exported by most commercial CAD systems.

2. Mask Generation

After data are received, the mask plate is charged through an “imagewise” ionographic process.The charged image is then developed with electrostatic toner.

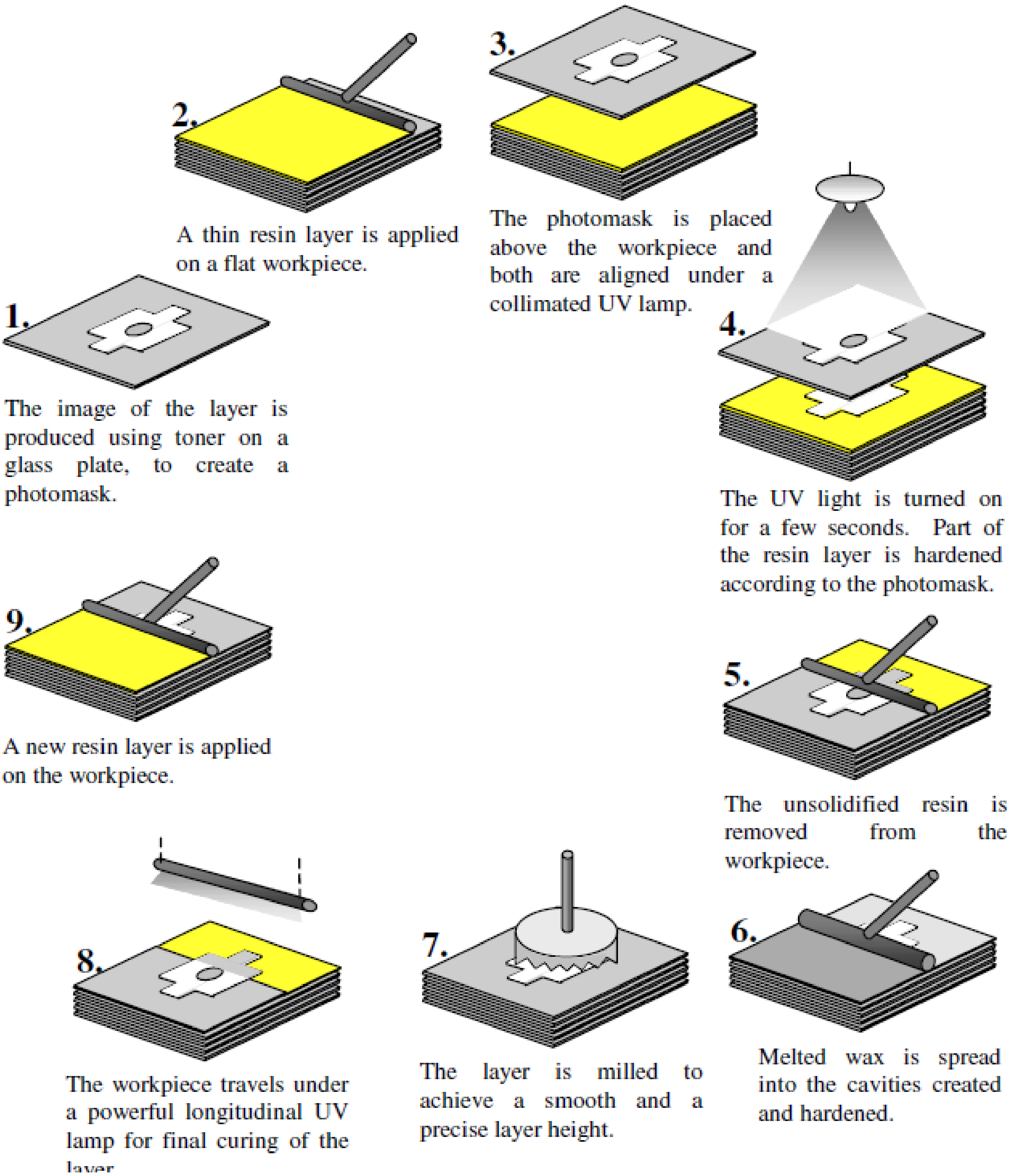


Fig: Solid Ground Curing process

3. Model Making

In this step, a thin layer of photopolymer resin is spread on the work surface (item 2). The photo mask from the mask generator is placed in close proximity above the workpiece, and aligned under a collimated UV lamp (item 3). The UV light is turned on for a few seconds (item 4). The part of the resin layer which is exposed to the UV light through the photo mask is hardened. Note that 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 workpiece (item 5). This is done by vacuum suction. Following that, melted wax is spread into the cavities created after collecting the liquid resin (item 6). Consequently, the wax in the cavities is cooled to produce a wholly solid layer. Finally, the layer is milled to its exact thickness, producing a flat solid surface ready to receive the next layer (item 7).

In the SGC 5600, an 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.

The main components of the Solider system are (see Figure 3.7):

(1) Data Front End (DFE) workstation.

(2) Model Production Machine (MPM). It includes:

(i) Process engine,

(ii) Operator's console,

(iii) Vacuum generator.

(3) Automatic Dewaxing Machine (optional).

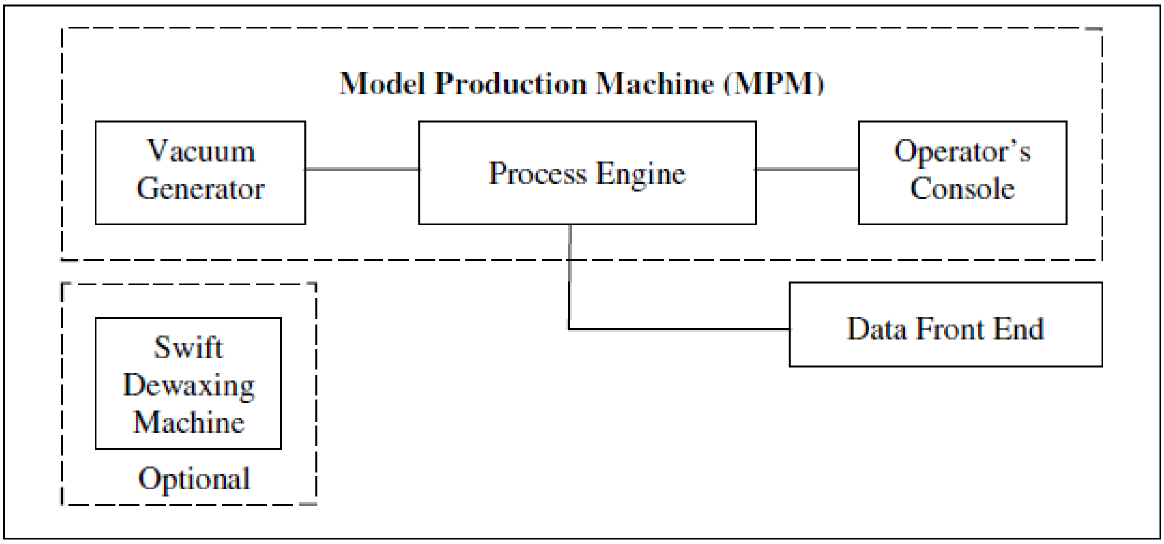


Fig: Solider system block diagram

SGC Principle:-

Cubital's RP technology creates highly physical models directly from computerized three-dimensional 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 the following principles:

(1) Parts are built, layer by layer, from a liquid photopolymer resin that solidifies when exposed to UV light. The photopolymerization process is similar to that described in Section 3.1.4, except that the irradiation source is a 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 an nonimpact ionographic printing process, a process similar to the Xerography process used in photocopiers 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 the 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.

(2) Multiple parts may be processed and built in parallel by grouping them into batches (runs) using Cubital’s proprietary software.

(3) 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 the vertical accuracy. This step also 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.

(4) 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.

Applications

The applications of Cubital's system can be divided into four areas:

(1) General applications. Conceptual design presentation, design proofing, engineering testing, integration and fitting, functional analysis, exhibitions and pre-production sales, market research, and inter-professional communication.

(2) Tooling and casting applications. Investment casting, sand casting, and rapid, tool-free manufacturing of plastic parts.

(3) Mold and tooling. Silicon rubber tooling, epoxy tooling, spray metal tooling, acrylic tooling, and plaster mold casting.

(4) Medical imaging. Diagnostic, surgical, operation and reconstruction planning and custom prosthesis design.