Accurate Rapid Prototyping by the Solid Ground Curing Technology

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The first stage of Rapid Prototyping life cycle as a new technology in the marketplace is gradually ending, and the second stage has already started. Many new vendors have introduced their products in this field, utilized different, new technologies or improvements of the existing ones. The first introduction of the RP concept and Stereolithography created a stunning impression in the marketplace. After a couple of years, as customers and users have gained much experience and understanding or RP technology, the first enthusiasm started making way to more serious and demanding approach. This is very well reflected in the thorough evaluations of the different technologies available today in the marketplace, done by customers looking for a technology that will best fit their needs. This is actually why most of us are here today.

One of the most common problems shared by many RP technologies is model shrinkage and distortion, considerably limiting the accuracy that can be achieved. In this case, "accuracy" should have only one meaning: the deviation of the model's dimensions from the designer's instructions. Although there are many interesting machine specifications that can be introduced, like the repeatability of the laser beam, or the accuracy of a certain mechanism in the machine, the really important thing is the accuracy of the model itself. In several technologies the responsibility to the model's accuracy is waived to the operator due to shrinkage effect, distortions and the need for supporting structure. This actually means that the more experienced the operator is, the better parts he will be making.

As a second generation technology, the Solid Ground Curing process developed by Cubital offers solutions to the inherent problems of presently known RP technologies, and do it independent of the operator's skills. Models built on the Solider 5600 system are accurate to 0.1% of any dimension. There is no final curing, there is no limit to the geometrical shapes that can be produced, no support structures are needed and several resins can be used by the system. The spacious production volume of 20" x 14" x 20" allows for the production of either one large model or many different smaller models that will be nested together and made in a single run. Higher safety and throughput are other benefits offered by this technology.

There are two major principles to Cubital's Solid Ground Curing technology:

1. The resin is exposed to UV flood light through a computerized programmable mask

2. The model is generated within a solid environment and not in a vat full of liquid

The process starts with the creation of three dimensional composition of the parts to be made in the next run and the definition of layer thickness. The Solider computer then slices the whole composition together into layers and generates a precise raster image of each layer.

This image is sent ot the mask plotting unit in the machine and a high resolution, precise optical mask is generated by means of electrostatic charges and black toner powder.

The optical mask is then positioned precisely above the workpiece which has already been spread with a thin layer of liquid photopolymer and under the high power UV lamp (2000W), ready to be exposed.

A shutter is opened for about 3 seconds and the resin is exposed and cured by the light passing through the mask. The pattern of the cross section of the model at this layer is fully cured due to the high power lamp and the length of exposure time. Unexposed areas on the layer surface remain in liquid state.

The mask, which is actually a plate of glass, moves back to the mask plotting unit and is being discharged and erased, ready for the next cross section to be drawn.

The workpiece now passes under an aerodynamic wiper that "sucks" away all the residual liquid from the surface, leaving behind only the cured pattern.

A thin layer of melted wax is then spread over the surface, filling in all the voids and cavaties left after the removal of the residual liquid. A cold plate is lowered onto the surface of the layer, cooling down the wax and solidifying it. Now we have fully solid layer that is made partly from plastic and partly from wax.

The workpiece now passes under a milling disk that trims off the layer's surface down to the desired thickness, creating a flat, smooth surface ready for the next layer. A new layer of liquid photopolymer is then spread and the whole process starts once again.

After the last layer is done, we have a block of wax, within which the model, or models, are embedded. The wax is melted away in a microwave oven, or by using a hot air gun or even using plain warm water and the finished model is ready for use.

If we now go back to the issue of accuracy, we can see how it is achieved in this technology. In the X and Y direction it is achieved by the full curing of the patterns, and by the highly accurate mask. In the Z direction it is achieved by the precise milling of each layer down to its desired thickness.

Some other benefits that this technology offers are:

* Shrinkage effect has been minimized due to the full cure of every layer

* No final curing in a special oven is needed

* No support structure is needed, the wax supports the model in all directions

* Models structural strength and stability are higher and the models are much less brittle. This is due to the curing process that minimized the development of internal stresses in the structure.

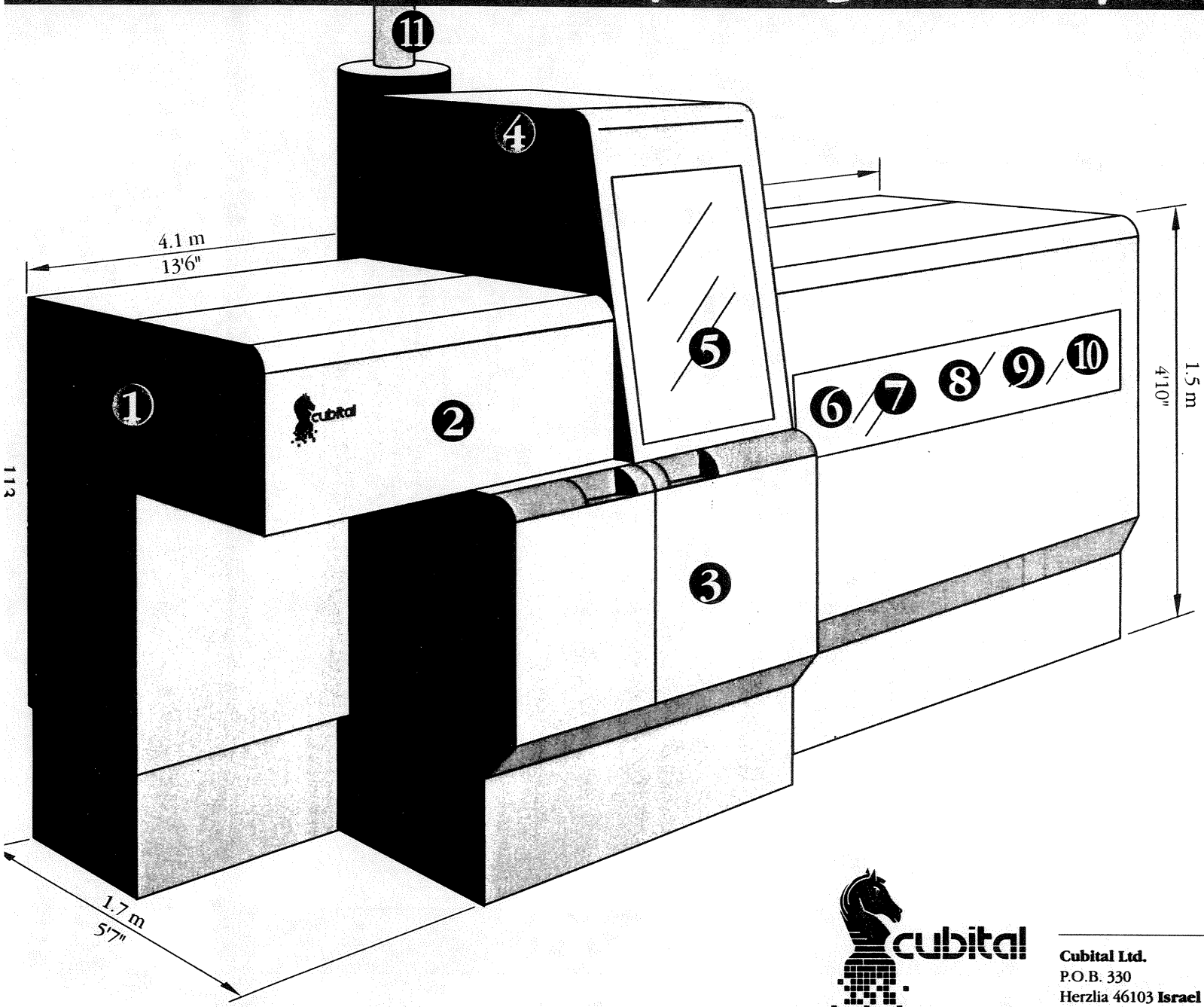
* Any geometrical shape can be made without limitation

* High throughput is achieved due to the three dimensional nesting of models within the wax

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

* By altering the process slightly, wax models can be made and be used in the lost wax casting process.

The Solider system general layout



1. MASK PLOTTER
2. OPTICAL MASK on a FLAT GLASS PLATE
3. WORKPIECE CARRIAGE
4. HIGH POWER UV LAMP
5. EXPOSURE CELL
6. RESIN APPLICATOR
7. AERODYNAMIC WIPER
8. MILLING HEAD
9. WAX APPLICATOR
10. COOLING PLATE
11. AIR EXHAUST

Solider dimensions -

L: 4.1 m / 13'6"
W: 1.7 m / 5'7"
H: 1.5 m / 4'10"

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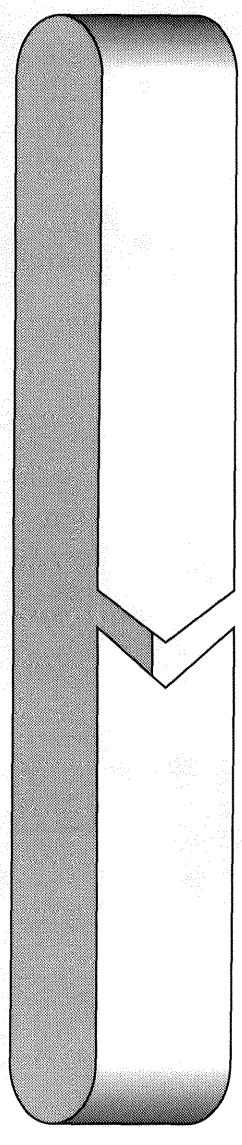
The solider model building process

The workstation operator creates a three dimensional composition of the models to be included in the next run and determines layer thickness. The Solider Software slices the composition into layers and generates a precise raster image of each layer. Then, the following process repeats for each layer:

(See highlighted components on reverse side)

The model growing cycle



The raster image is sent to the **mask plotter**, and is converted into a high resolution **optical mask** on a **flat glass plate.**

The **optical mask** is positioned precisely above the **workpiece** under the **high power uv lamp**, ready to "print" the new layer.

A **shutter** is opened for a few seconds, and the resin is cured by the light passing through the mask. The correct pattern is fully cured while the "masked" areas remain in liquid state.

The mask on the glass plate is erased and the plate is cleaned for the next layer's mask.

The workpiece passes under an **aerodynamic wiper**, that collects all the uncured liquid resin, and leaves the cured areas intact.

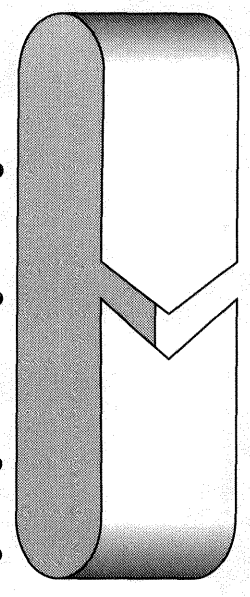
The workpiece passes under a **wax applicator**, where melted wax is spread on top of the layer, filling all the cavities left by the liquid resin that was wiped off.

A **cooled plate** is pressed down onto the layer, instantly solidifying the wax, thus creating a perfect solid support.

The workpiece passes under a precise **milling disk** that trims the layer's surface down to the specified thickness and leaves a flat surface, which is an ideal substrate for the next layer.

The workpiece is lowered by one layer-height, and passes under a **resin applicator** that covers it with a thin layer of resin, ready for curing the next layer.

The mask-plotting cycle



After completing the last layer, the workpiece - composed of a bulk of wax within which several models are embedded - is removed. The wax is then either melted or rinsed and the models are ready for use.

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