LAMINATED OBJECT MANUFACTURING-LOM

Lecturer dr.ing. Florin **CIOFU, Lecturer dr.ing.** Alin **NIOAŢĂ,**
University "Constantin Brâncuşi" of Târgu-Jiu

Abstract: *The fabrication of stratified pieces (LOM) is a fabrication method where a 3D model is constructed by adding, pasting and cutting the sections in a cycle that repeated starting with the first layer at the bottom of the piece and ending by the last layer at the top of the piece.*

Keywords: laminated, polyvinyl, rapid prototyping;

1. Introduction

The fabrication as quick as possible, with a cost as reduced as possible of a model or of a new product has been a dream of any technologist engineer. Starting with the '90s, this dream has turned into reality every day due to the appearance and the implementation in the industrial practice of the technologies of quick fabrication of prototypes (Rapid Prototyping - RP) that are basically different from the technologies known and used until that moment.

As a notion, the quick prototyping is associated to a number of relatively new technological proceedings allowing the quick accomplishment of the physical model, of the functional prototypes, of the reference points, of the sub-ensembles or of the tools involved in the developing process of the product.

These techniques of quick prototyping use another principle for materializing the piece, by adding material as much as needed and where it is necessary for the tools.

The result followed by applying these technologies is the accomplishment in a short term and with a negligible additional investment of a limited number of samples of:

- the actual product;
- a copy (full-scale or made of another material) of the product in different stages of development;
- tools and devices necessary in order to achieve the product, in order to validate the creation conceptions to the current phase, different tests and the following orientation of the developing approach of the product.

A classification of the quick fabrication technologies of the prototypes suggests a grouping of these technologies in two categories:

- forming technologies by depositing material;
- modelling technologies by sampling material.

The method studied in this paper is *Laminated Object Manufacturing (LOM).*

The principle: The first LOM fabrication system was developed in 1991 by Helisys company. In LOM, the obtaining of the layers composing the piece is made by cutting from a sheet of solid material (paper, polyvinyl), by using a cutting element (infrared laser, diamonded point knife, etc)(fig.1).

The material that does not form the current layer will be removed by hand at the end of the process. Once every layer is finished, it is connected to the previous one, by using an adhesive (placed on the inferior side of the sheet) activated or not by the heat.

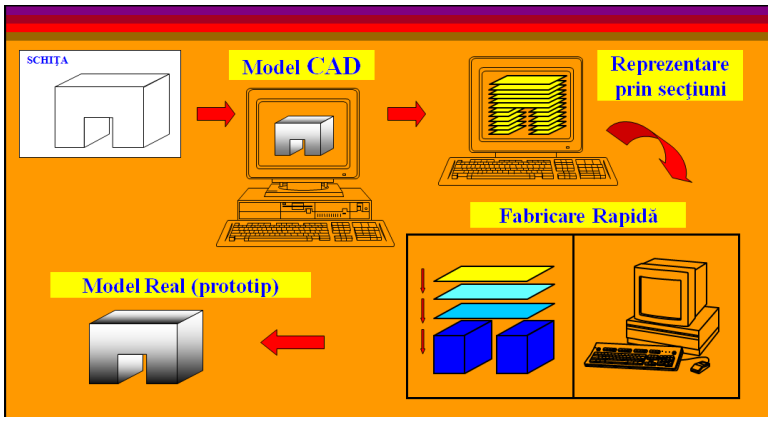


Fig.1. *Rapid prototipyng – LOM.*

At present, there are several materials used for LOM: paper, plastic or composites. At the end of the process, the piece is wrapped in the material in excess that must be removed; due to this fact, the LOM process is the most adequate for small or average sized pieces without complicated details.

Advantages: good accuracy, big scale construction. Disadvantages: a limited scale of materials, weak properties of the materials, the support removal is needed.

The devices used in order to obtain such pieces in a *Rapid prototyping* system are called 3D Printers.

2. Work Principle

The fabrication of stratified pieces (LOM) is a fabrication method where a 3D model is constructed by adding, pasting and cutting the sections in a cycle that repeated starting with the first layer at the bottom of the piece and ending by the last layer at the top of the piece.

Fig. 2. *SolidoSD 300 Pro Machine - « Constantin Brâncuşi » University*

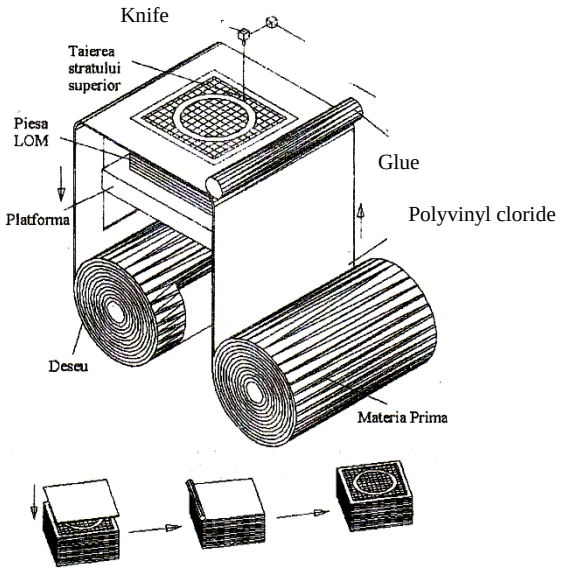


Fig.3. *Working principle of technology LOM*

The model of the 3D printer on which there were accomplished the experimental researches presented in this paper is Solido SD 300 Pro (fig.2) and it belongs to the Researching Laboratory of the Industrial Engineering Chair within the Engineering Faculty of "Constantin Brâncuşi " of Târgu Jiu.

In the first place, the piece is represented 3D by means of a graphics programme assisted by the computer, for example: AutoCAD, Solid Works (fig.43), CATIA, etc, and then it will be saved in a *STL file (fig.5).

This method of quick fabrication starts from the *.STL file of the piece to be processed, that is also taken over by the soft of SOLIDO SD 300 PRO device. We accomplish the sectioning of the 3D model in layers of equal width with the width of the sheet of chloride polyvinyl and we calculate automatically the profile of the piece of every section, which will be cut by means of the cutting point.

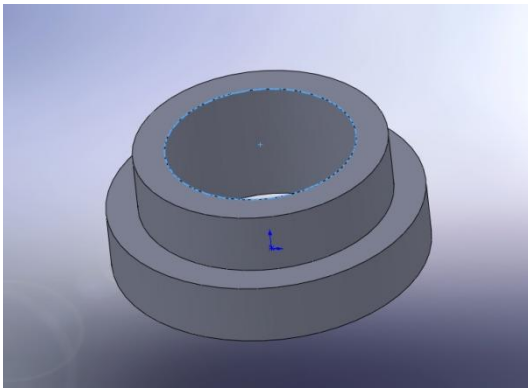


Fig.4. *3D show piece. (Solid Works)*

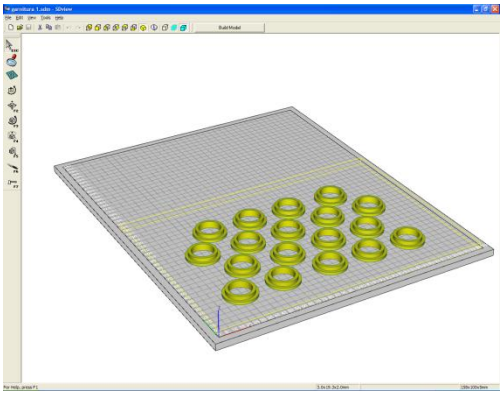


Fig.5*. *STL file.*

The cutting starts with the inside/outside profile of the section by the piece at the respective z level. Then, it is the cutting according to the hatching of the material in excess and it ends by the cutting of the inside/outside profile of the box.

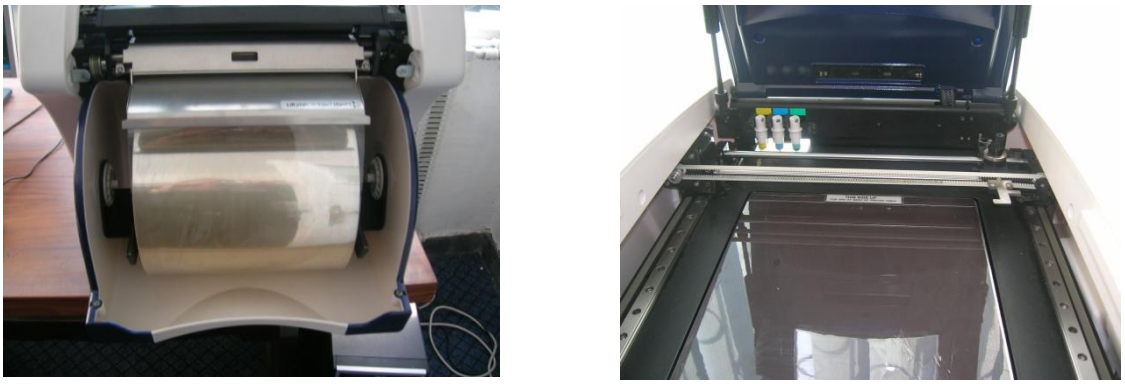
Next, the sheet advances at the same time with the width of a layer so that at the previously built package we add a new layer of material. The roll of adhesive depositing will scroll on the surface of the new layer of material and will paste it on the previous layer by adhesion and pressing.

Then, we go back to cutting and the construction process of the piece ends when the height of the package contracted by depositing successive layers of material reaches the z_{max} level of the piece.

SDView software is an application of 32 bytes, with the interface with dialogue windows, progress indexes etc. SDView is completely integrated with the device equipment, allowing the pre-processing, the execution of the sections by the piece and the control of the device in only one programme.

The lamination system is represented by a roll of chloride polyvinyl sheet (fig.6.a), whose position to the working platform is controlled by means of a micro-switch.

The layers adhere one to another by means of an adhesive distributed on the sheet surfaces right when it advances in order to constitute a new layer, by means of a depositing roll.



a b

***Fig.6**. a) –Polivinyl cloride roll ; b) – Cartidrge anti-glue.*

In order to detach more easily the elements that will subsequently be removed, in the respective areas the device deposits an anti-glue that annuls the pasting effect of the adhesive previously deposited on the entire surface (fig.6.b).

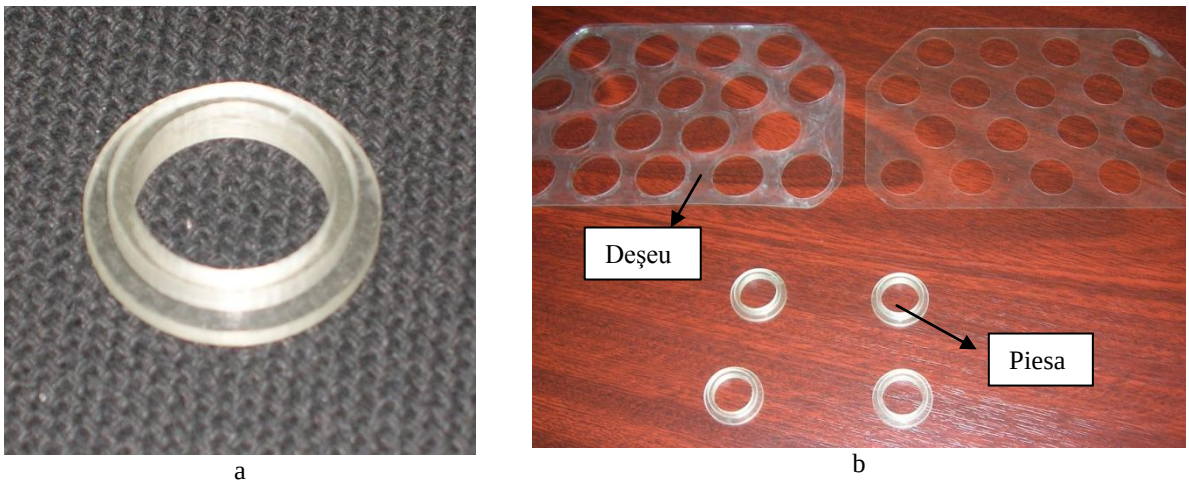
The fabrication time depends not only on the piece gauge but also on its complexity featured by the number of triangular plan faces by means of which it can be estimated.

3. Experimental results.

The piece – Gasket– was modelled 3D (fig.4) by means of the Solid Works graphics programme and saved in a *STL format.

STL is a file format native for the CAD Systems 3D stereo-lithography softwares. This file format is carried by many types of software used on a large scale in order to accomplish Rapid Prototyping and by a fabrication assisted by the computer.

The *STL files describe only the tri-dimensional geometry of the surface of an object, with no representation of colour, texture or other attributes common to CAD model.



a b

***Fig.7.** a) – Piece « Gasket » ; b) – Piece, and waste*

Thus, due to the existence of the 3D model, by means of the SDView soft, the printer has constructed the piece resulting the prototype, layer by layer (fig.7.a).

After completing (detaching) the piece, the remained material represents the waste that is, unfortunately, irrecoverable (fig.7.b).

4. Conclusions.

We have tried to find the optimal technological parameters for every piece, considering its features related to the form, the gauge, the required accuracy, etc.

By means of the accomplished experimental researches, of the fabrication of the RP models on the SOLIDO SD 300 PRO device, there were brought important constitutions in the following directions:

- optimizing the technological parameters for cutting in X-Y plan;
- optimizing the pasting system of the successive layers, in order to improve the accuracy n the Z axe of the fabricated piece;
- optimizing the orientation of the pieces during the construction;
- the possibility to estimate the behaviour of different types of LOM models, in certain work conditions, by means of a better comprehension of the fabrication process.

One of the evaluation criteria of the FRP technologies is the accuracy of the RP fabricated models, especially because accuracy is not a strong point for any of the FRP proceedings. These FRP technologies have many advantages (referring to the possibility of quick fabrication of some pieces, as complex as they are), but the accuracy is comparable to the one obtained by the classical technologies of lathing, finishing of finishing milling.

It was also found that the main factors influencing the immediate and long-term stability of the shape of the LOM models are:

- the comprehension force of the roll that pastes and presses the layers for pasting. This comprehension force creates residual tensions contributing to the change of the piece shape, after finishing its fabrication.
- the inter-laminar tensions of the adhesive layers that, after pasting, suffer distortions causing residual tensions, too.
- the lack of compensating the radius of the cutting knife causes errors in the x-y plan.
- the humidity absorption of the sheet used for the fabrication of the LOM pieces also provokes significant elongations of the model sizes.

Even if the process enjoys a large industrial use, we consider that, in the future, we will have to intensify the researches for the analysis of the LOM process, by a modelling of a process, by using methods of computational analysis that should consider the pressure, the temperature, the thermal transfer, the humidity etc.

Anyway, by means of the accomplished experimental researches, we have also tried to bring an important contribution to a better comprehension of the LOM process and to the possibility to estimate the behaviour of certain shapes of pieces in certain conditions.

The LOM system offers a lot of flexibility regarding the system parameters: the cutting speed of the cutting point, the speed of the pasting roll, the roll temperature, etc. This flexibility sometimes involves difficulties, complexity and confusion, too.

In order to remove a few of these negative facts, we have accomplished experimental researches (by using SOLIDO SD 300 PRO device) regarding the influence of two of the most important factors of the LOM process: the pasting process and the cutting one.

As a result of numerous accomplished experiments, it was found that, when fabricating a new piece, the operator should always follow a procedure of optimizing the

technological parameters that, after choosing the type of the layer material and the cutting speed, should choose the actual cutting speed desired by him and then he should adjust it depending on the used cutting speed, in order to find the adjusted power that will actually be the value introduced as a parameter of setting the laser power, when fabricating this piece.

The pasting process of the successive layers during the fabrication of the pieces on the LOM device depends on the following factors:

- the speed of the pasting roll;
- the temperature of the pasting roll;
- the pressure exerted by the pasting roll.

The quality of pasting the layers obviously depends also on the quality of the used sheet. Even if it is a real hazard to recommend a set of optimal technological parameters for fabrication on SOLIDO SD 300 PRO device (even the producing firm did not dare this), as a result of the accomplished experimental researches, a set of optimal technological parameters is presented that may be used for the fabrication of the complex pieces on SOLIDO SD 300 PRO device.

From the accomplished experimental researches, there were deducted a few rules that are recommended to be considered when fabricating the models on SOLIDO SD 300 PRO device, namely:

- when loading the *STL file, we should accomplish a simulation of the sectioning, in order to prevent the problems that may appear due to the lack of certain faxes (deficiency connexions-STL files with flaws), or due to certain incorrectly defined objects;
- the platform astride should be accomplished after every one of its pre-instalment. The astride provides the platform horizontality and should be checked with calibrated rolls;
- at the beginning, we may work with a smaller speed of the pasting roll (ex.140mm/s), until the piece gets warm, and after that it is recommended the slight increase of the roll speed (to about160mm/s) ;
-after the first layers deposited in the piece, we may check (command Ctrl+P) :

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