ANNALS of the ORADEA UNIVERSITY.
Fascicle of Management and Technological Engineering

# PARTICULARITIES IN MANUFACTURING RAPID PROTOTYPES ON SINTERSTATION 2000 SYSTEM

**Adina PINTEA**

Technical University of Cluj-Napoca, Adina.Pintea@tcm.utcluj.ro

**Abstract**: The present paper shows the importance of the characteristics and factors that interfere in manufacturing of rapid prototypes from different powders on selective laser sintering system machine: Sintestation 2000. These factors, like orientation of the parts on the building area of the machine, the setting of the technological parameters or the precision of the 3D models are very important issues in manufacturing and are surely saving time and money if the manufacturer controls and optimizes them.

## 1. INTRODUCTION

Selective laser sintering machine, Sinterstation 2000 has the ability to create complex parts and prototypes from different powders materials: polyamides, metals, polystyrenes and other materials.

SLS process implies building a rigid object from a powder material. Selective laser sintering uses a laser beam radiation to local sinter of the powder layer. The main difference between SLS system of the metals and the plastics is regarding optical system and the laser, because a 900 °C temperature asks a bigger energy power of the laser beam. For this reason, the diameter of the laser beam is reduce to 350 μm and the laser power is increased at 200 W. Power density of the laser has to be increased from 25 W/mm$^2$ for plastic powders to 700 W/mm$^2$ for metallic powders.

The principle of the selective laser sintering is shown in figure 1.

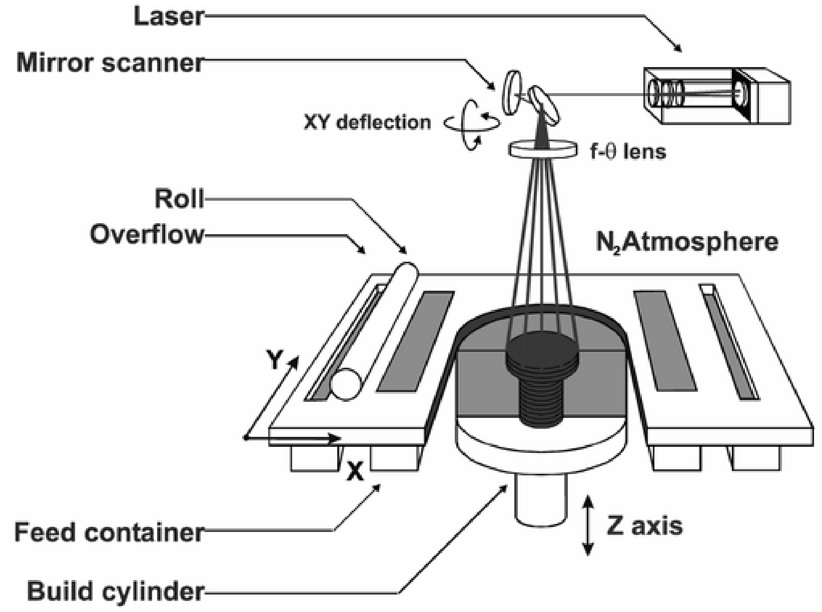

Fig1. The principle of the Sinterstation 2000 system

The particularities of this system are very important to know because it can offer the possibility to optimize the entire process before manufacturing and also to prevent the possible errors of manufacturing.

## 2. PARTICULARITIES REGARDING THE ORIENTATION OF THE PARTS ON BUILDING AREA ON SLS SYSTEM

In a SLS process, a designer follows to increase the efficiency of a build through manufacturing simultaneous of more possible parts, parts that may fill the entire work area and the volume in use. Stacking one part over another will lead to a higher efficiency. However the utilization of the maximum workspace is not always feasible. For example there are some limitations of the CAD system, like the difficulty in slicing a number of STL models due to the limitations of the computer memory.

Efficiency may be obtained as a ratio of the volume of the parts with the total volume of the workspace. However, as packing along the z-axis is in general not necessary, the volume in-use should be consider instead of the total workspace volume.

Figure 2 illustrates the volume and the height of the material deposition and that of the workspace of the SLS machine.

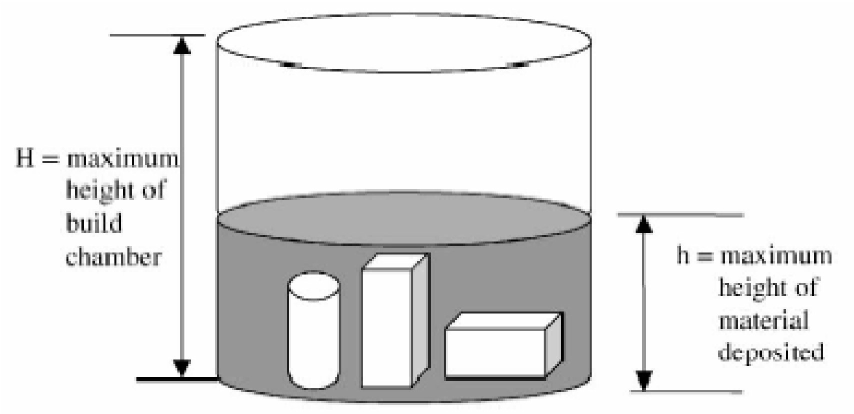

**Fig. 2.1 Comparison of the total volume and the volume in-use**

The workspace volume occupied by a part may vary with its orientation. For example the volume occupied by a rectangular box orientated at 45˚ is more than it is orientated at 90˚ or 0˚ to its base.

Orientation efficiency means the material used for a single part or for a number of parts packed in the workspace volume. Therefore, orientation efficiency can provide a better estimation of powder material consumed and the cost involved manufacturing the part(s). Based on the figure 2 it can be written the equation of the orientation efficiency:

$$\text{Orientation efficiency } (\eta) = V_p / (h_m * A) \qquad (1)$$

Where:

$V_p$ – volume of the part (enclosing in a box) ($mm^3$);
$h_m$ – maximum material height (mm);
A – workspace area ($mm^2$)

In the following are presented some possible orientations of the parts and their optimum way of positioning on the workspace area of the Sinterstation 2000 system.

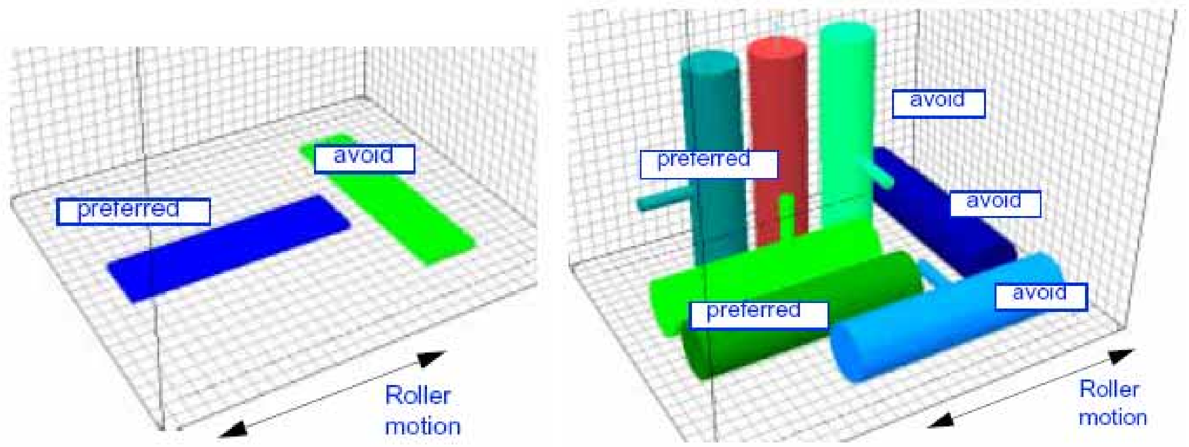

**Fig.2.2 Different types of parts and their preferable orientation**

From figure 2.2 it can be seen that rectangular parts should be positioned and orientated in the building packet so that the length of the part should be on the same direction with the roller movement. If it is necessary the rotation of some parts, in perpendicularly way to the direction of the roller motion for a better enclosing in the workspace area, then is better to put the parts in the middle of the building area and to insert the parts with parallel orientation to the roller motion.

For the SLS building of a horizontal cylinder is optimum to orientate it in the roller direction of movement to avoid the phenomenon of shifting and to build it faster. If you want to obtain a better surface finish then you should orientate the cylinder vertically as it is shown in figure 2.2.

## 3. PARTICULARITIES REGARDING THE INFLUENCE OF THE TECHNOLOGICAL PARAMETERS ON THE PARTS ACCURACY AND QUALITY SURFACE

The technological parameters of the Sinterstation 2000 are very important because they influence the accuracy, the quality surface and the mechanical properties of the final part(s). From these parameters that interfere directly in a SLS process building I can remind the most important of them: *the laser power*, *the temperature*, *the atmosphere* inside the working space, *the scanning speed*, the *roller speed* or the *layer powder thickness*.

*Laser power* can vary depending on the material used for sintering, from 5-7 W for polyamides to 24-27 W for metallic powders. Laser power is used to successively sinter every section of the part. Therefore, it may appear some difficulties in setting the laser power. For example, when there is an excessive laser power it may affect the outside area of the parts, causing nonflatness. When the laser power is insufficient the result is porous parts, cracking final parts.

*Temperature* is a factor that can caused shrinkage, dilatations and bottom curving parts. These manufacturing problems are due to heat transfer from bottom-up. Namely, on building time process, because of the temperature variation at a time with building the layers there is a temperature variation phenomenon at a time with building every layer. Bottom-side curving of the parts, especially on their manufacturing from metallic powders is due to the ascending heat flow and also due to the layering process.

The accuracy of the parts, especially of the metallic moulds made by SLS depends on some factors: CAD model, slice algorithms, powder grain size, laser beam deflection or shrinkage.

Another factor of great importance in the process of selective laser sintering is the layer thickness of the powder. This thickness is defined as the depth which piston descends at every layer deposition. This layer thickness often creates “stair-step-effect”, an unwanted thing that may appear at manufacturing. As it can be seen in figure 3 for a constant layer thickness, the stair-step-effect is visible when the inclination angle of the surface of the model is smaller in comparison with horizontal plane.

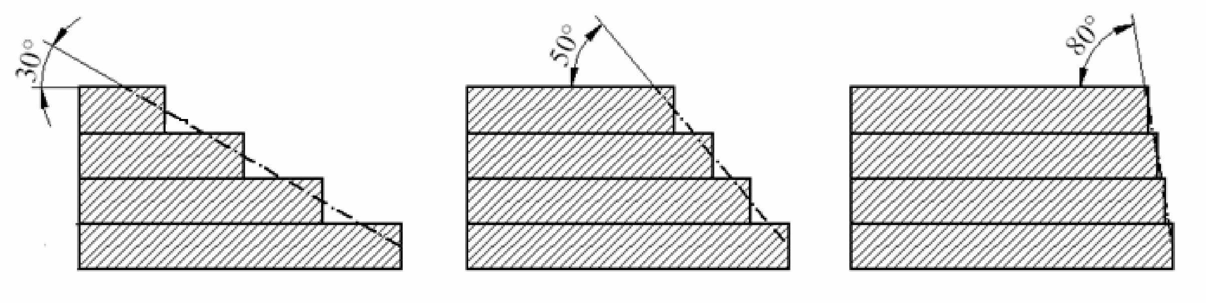

Fig.3 The influence of the inclination angle on stair-step-effect

The stair-step-effect appears especially on curve surfaces and inclined planes.

## 4. CONCLUSIONS

The importance of a good controlling of the Sinterstation 2000 system depends on optimizing the technological parameters: laser power, temperature and atmosphere. The parts or prototypes made by SLS have to be controlled from their 3D modelling, through STL saving files to proper manufacturing from powder and even post-processing (in the case of metallic parts). The orientation of the parts in the work area has a great role on the accuracy and quality surface of the final products. To increase the efficiency of a packet manufacturing is better to take into account the possibility of optimum orientation, function of part(s) dimensions, complexity and not at least the material.

## References:

1. Bâlc, N., Tehnologii neconvenționale, Editura Dacia, Cluj-Napoca, 2001
2. Berce, P., Bâlc, N., Ancău, M., Comşa, S., Jidav, H.,Caizar, C., Chezan, H., Fabricarea Rapidă a prototipurilor. Editura Tehnică, Bucureşti, 2000.
3. Choi S.H., Samavedam S, Choi S.H., Samavedam S, Visualisation of Rapid Prototyping, Computers in industry 2002