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# THE QUALITY OF PARTS REALIZED ON THE RP MACHINE (LOM, FDM, SLS)

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**Key words:** rapid prototyping, laminated object manufacturing, fused deposition modeling, selective laser sintering, roughness.

**Abstract.** The paper presents the obtained roughness of the parts manufactured by three non-conventional manufacturing techniques, using the Rapid Prototyping systems LOM-1015 (Laminated Object Manufacturing), FDM-1650 (Fused Deposition Modeling), SLS – Sinterstation 2000 (Selective Laser Sintering). The quality of the parts is analyzed and discussed, using a comparative study.

## 1. INTRODUCTION

RP includes technology methods, which release automatic physical models from CAD models. These 3D scanners allow the designer to create rapid prototyping parts for evaluation test and to identify the mistakes of the design before starting the production.[2]

The easiest way to estimate an 3D model is by approximating with lots triangular sides. This method was used for the first time by the american company 3D Systems, who realized for the first time a RP machine – Stereolitography Aparatus – which used a 3D model STL, as a first element (Fig. 1)

An STL file is what your RP model is generated from, therefore is it important to create a high quality file. An STL file is only a representation of the true CAD model. It is a digital file that can be compared to a fancy point cloud. Points are placed all over the true CAD surface and then connected to form a quilt made of small triangular plates, each with its own normal defining surface direction. Higher density on non-flat surfaces results in a more accurate representation of your CAD model. Most CAD packages allow you to enter a tolerance when exporting an STL file.[5]

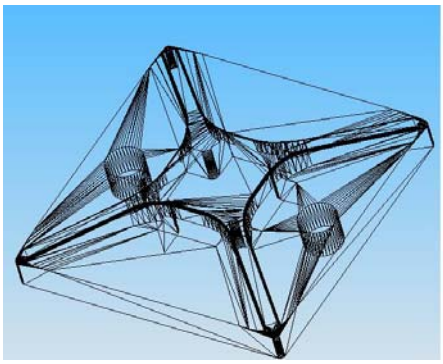

***Fig. 1. STL model***

## 2. MANUFACTURING OF THE PART BY USING THE SYSTEM LOM 1015

The whole equipment is controlled by the computer. This process includes examination of laser system, the feeder mechanism of the paper, the temperature and the driving mechanism of the platform.

This method includes 3 main stages:

a) pre-processing

Using the STL file, LOM Slice creates *bmp* file and than generates the 3D image on the screen of the computer and the file *con,* which contains the list of triangular connections.

b) the manufacture of the part

The original material consists of paper laminated with heat-activated glue and rolled up on spools. As shown in the figure below, a feeder/collector mechanism advances the sheet over the build platform, where a base has been constructed from paper and double-sided foam tape. Next, a heated roller applies pressure to bond the paper to the base. A focused laser cuts the outline of the first layer into the paper and then cross-hatches the excess area (the negative space in the prototype). Cross-hatching breaks up the extra material, making it easier to remove during post-processing (Fig. 2). During the build, the excess material provides excellent support for overhangs and thin-walled sections. After the first layer is cut, the platform lowers out of the way and fresh material is advanced. The platform rises to slightly below the previous height, the roller bonds the second layer to the first, and the laser cuts the second layer. This process is repeated as needed to build the part, which will have a wood-like texture (Fig. 3). [1]

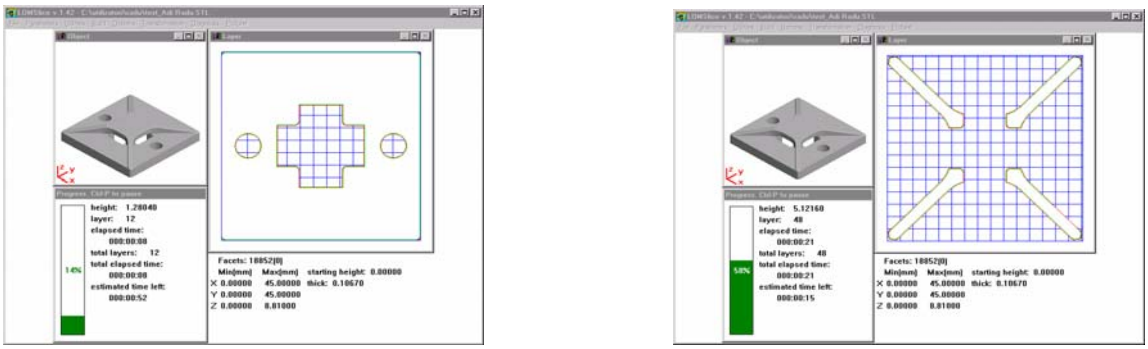

***Fig. 2. The LOMSlice interface***

c) post-processing

This includes the separation the workpiece from the workpiece support and than polishing of it, because the models are made of paper, they must be sealed and finished with paint or varnish to prevent moisture damage.

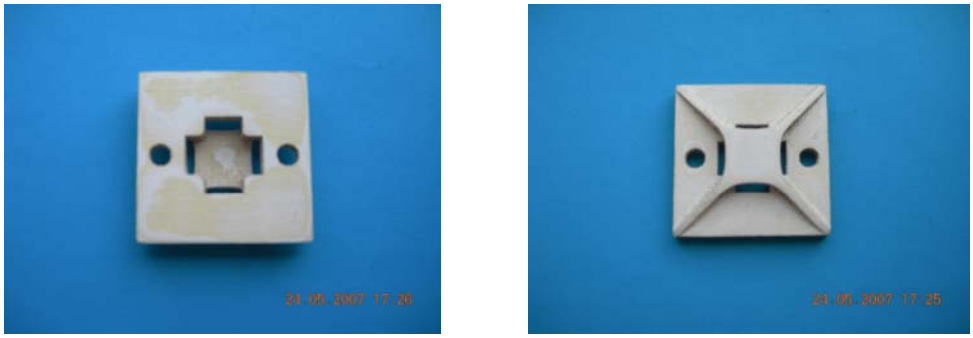

***Fig. 3. The LOM part***

## 3. MANUFACTURING OF THE PART BY USING FDM 1650 SYSTEM

The process of manufacturing of the FDM prototype (Fused Deposition Modeling) was licensed by the american company Stratasys Inc in 1992. The Stratasys makes a variety of FDM machines ranging from fast concept modelers to slower, high-precision

machines. Materials include ABS (standard and medical grade), elastomer (96 durometer), polycarbonate, polyphenolsulfone, and investment casting wax.

The process of manufacturing of the forms using this technique follows 3 phases: the pre-processing, the manufacturing and the post-processing one.

a) pre-processing

In this phase, STL model is charged using the QuickSlice programm (this programm generates activation code of the mashine). After being able to read the data of the STL model, the next steps is orientation in the framework, so that the manufacturing of the part should be efficient considering the time and the material we used (Fig. 4).

This kind of orientation is usually made through Ouick Slice's program specialized functions (like turnning, translation, mirroring). After the orientation of the STL file, takes place the slicing this file and the building of the suport material.

The QuickSlice programm coordinates the roads of the coping action material. The final operation consists is saving all of the data in a SML file (SML – Stratasys Modeling Language) and all of it will be transmitted to the computer of the FDM machine.

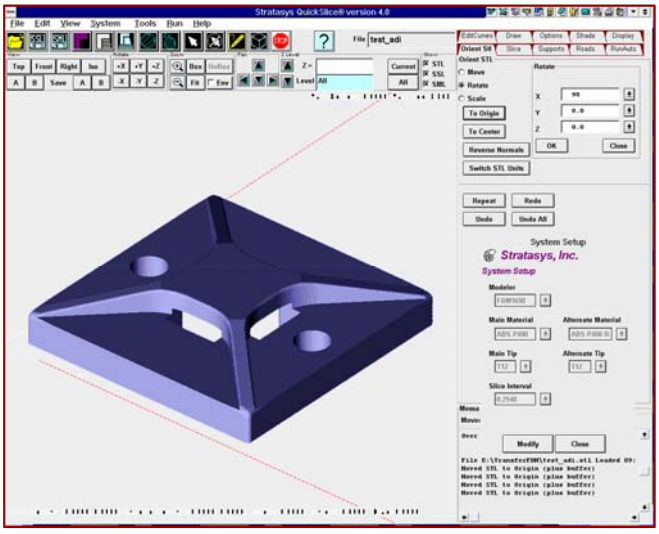


***Fig. 4. The QuickSlice interface***

b) the manufacture of the part

In this technique, filaments of heated thermoplastic are extruded from a tip that moves in the x-y plane. Like a baker decorating a cake, the controlled extrusion head deposits very thin beads of material into the build platform to form the first layer. The platform is maintained at a lower temperature, so that the thermoplastic quickly hardens. After the platform lowers, the extrusion head deposits a second layer upon the first. Supports are built along the way, fastened to the part either with a second, weaker material or with a perforated junction.

c) post-processing

- removal of the part from platform;
- removal of the suports from part;
- cleaning of part (wiping, rinsing, etc);
- finishing part (sanding, polishing, etc) (Fig. 5);


***Fig. 5. The FDM part***

## 4. MANUFACTURING OF THE PART USING SLS – SINTERSTATION 2000

The technique uses a laser beam to selectively fuse powdered materials, such as nylon, elastomer, and metal, into a solid object. [3].

a) pre-processing

STL file is imported in the system of the machine and the orientation of the „work area" is realized considering in the shapes so that the high measure of the part to have a minimum value on z axis. The final price of the part will be influenced by the time of the manufacturing and the high of the part on the axix z.

b) the manufacture of the part

Parts are built upon a platform which sits just below the surface in a bin of the heat-fusible powder. A laser traces the pattern of the first layer, sintering it together. The platform is lowered by the height of the next layer and powder is reapplied. This process continues until the part is complete. Excess powder in each layer helps to support the part during the build (Fig. 6).

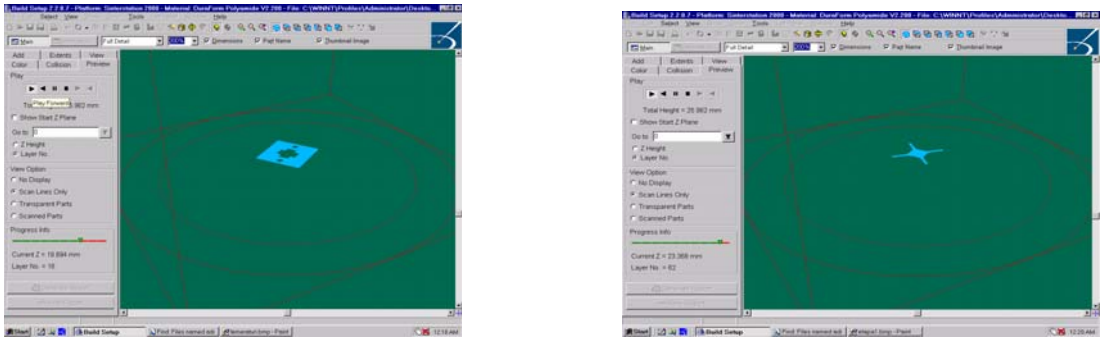

***Fig. 6. An intermediate phase of the manufacturing process***

c) post-processing

The part (Fig. 7) is obtain by taking out unsintered powder, by taking off the excess of the material; the powder takes place of the suport powder. For obtaining aesthetic models also theses can be impregnated with acrylic resin or epoxidic and than polished and dyed.

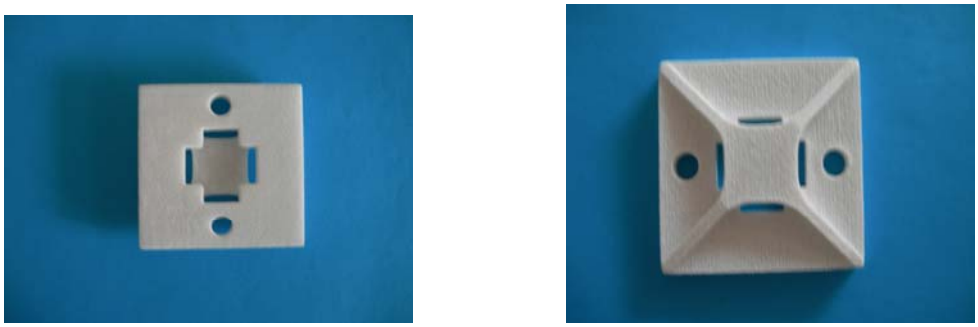

***Fig. 7. The SLS part***

## 5. THE MEASUREMENT OF THE ROUGHNESS SURFACES

The electronic roughness tester of Mitutoyo company which is used for measuring is a special device, which has a portable digital screen and an inside printer. Data obtained can be downloaded by any computer.

The electronic roughness tester SJ-301 (Fig. 8) measures 35 parameters of evaluation, 3 analyzed graphics and has important role in processing of date statistically speaking for obtaining complex data.[5]

***Fig. 8. The electronic roughness tester SJ-301***

The roughness measured is established when the manufacturing process is done, using 3 rapid prototyping method (fig. 9 – a, b, c).

Adjustable rod of the detector is moving on surface of the part and the distance of 12mm is the highest point, than can reach.

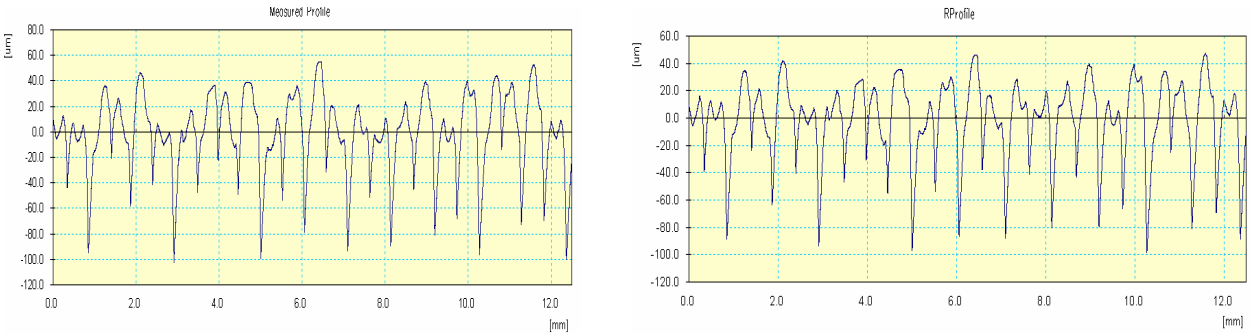


***Fig. 9. The obtained roughness a – LOM part***

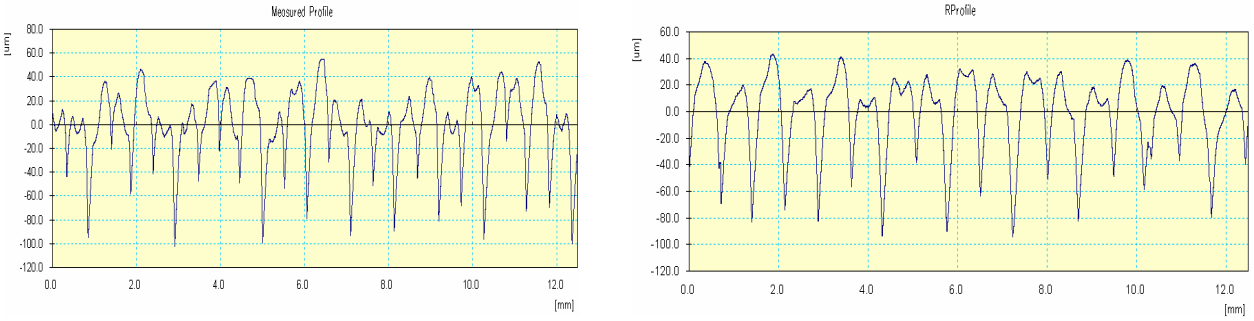


***Fig. 9. The obtained roughness b – FDM part***

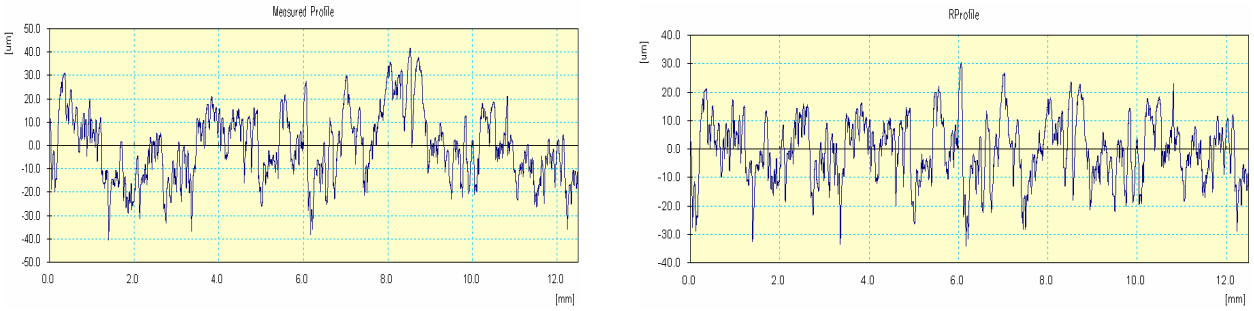


***Fig. 9. The obtained roughness c – SLS part***

The result of the roughness measuring are presented in Table 1.

**Table 1**

*Results of the roughness measuring*

| | Ra $\mu m$ | Rz $\mu m$ | Rq $\mu m$ | Rt $\mu m$ | Rp $\mu m$ | Rv $\mu m$ |
|---|---|---|---|---|---|---|
| LOM part | 22.12 | 133.8 | 28.21 | 145.8 | 42.11 | 91.65 |
| FDM part | 20.38 | 124.9 | 27.12 | 137.7 | 38.3 | 86.55 |
| SLS part | 8.91 | 54.26 | 10.91 | 64.29 | 22.87 | 31.39 |

## 5. CONCLUSION

The manufacturing accuracy and quality was not very high. The parts produced on the SLS – Sinterstation 2000 machine was better, as compare to the parts produced on LOM-1015 and FDM-1650 machine.

The surface quality is better within the x-y horizontal planes, and decreases on z axes.

## REFERENCES

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