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On the technological and dimensional considerations for generating parts by 3D-printed with light processing focus

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Abstract. The paper takes into account the specific process of generation and parameters setting of 3D printing process DLP (Digital Light Processing) which have an influence on the characteristics of planar surface of the parts. In the first part of the paper the study is conduct to determinate the parameters which can influence the process of implementation of flat surfaces pieces with 3D DLP process printing. In this part there is and a comparison with the method of generating the marker method 3D printing FDM (Fuse Deposit Modelling). It has chosen this solution because on the one hand the cost of parts are medium, as well as generating principle is relatively simple in terms of technological point of view, but as well as the accuracy and quality of surface generation made with this printing is much better than that provided by the process of asking for a comparison is made. Analysis of the surface will be done so about using an optical microscope with a magnification of 0-500 times, and by means of an electronic measure for dimensional parts as well as for spatial areas of the deviations generated. In it also make references to the methodology of generating flat surfaces and to influence the way their generation characteristics of the parts generated by the 3D printing process type DLP. It should be pointed out that from the perspective of the characteristics of the surfaces generated in literature there are few references in this direction being those areas indicated in the area, as well as acting, although the products have engineering applications.
Key words: *3D printing; fabrication parts; 3D modeling; 3D printing with DLP; CAD-CAM*

1. Introduction to 3D printing process DLP type

The process of 3D printing parts by DLP (Digital Light Processing) system is a relatively new generation for the parts. It consists in generating layers of materials converted from liquid in solid form as a result of the presence of a spot of light that produces the phenomenon of photo polymerization of the material subject to the generation process.

In terms of the process we distinguish several different parts. The first part is related to the equipment with which it used in the printing. From a constructive point of view, it is equipped with a screen and a vertical system of displacement of the element in which it is carried out the arrangement of layers. In Figure 1 it is possible to see the structure of such a printer which is used for generating parts. The printer it is an ANYCUBIC Photon printer.

For the experimental program was designed a plan part to be the main elements of which were envisaged in the context of experimental study. They were cylindrical surfaces, surfaces, air vents and the cylinders Figure 2. The part are made in Fusion 360 MODEL tab and save as .stl file to be made the CAM (Computer Aid Machine) program for 3D printing Figure 3.

To be able to achieve the printing process we'll use part of verification and program generation PrintStudio.

The layer generation can be made with a dedicated slicer which divide the spatial volume in static image with black and transparent part of the layer. The transparent part of layer is exposed at UV violet color by a lamp. In the process of printing 3D DLP type it is possible to change both the length of time of exposure to light purple and guidance module of the part of the printing process. Due to this fact has developed a research direction orientation's influence on the characteristics of three-dimensional parts.

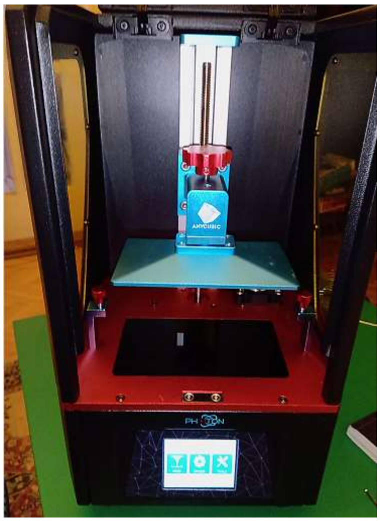


Figure 1. ANYCUBIC Photon printed used to print the parts

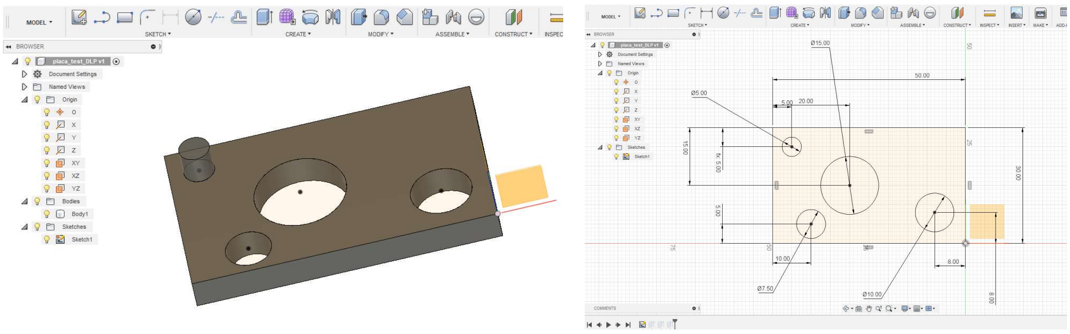


Figure 2. Design of the part use to printing DLP

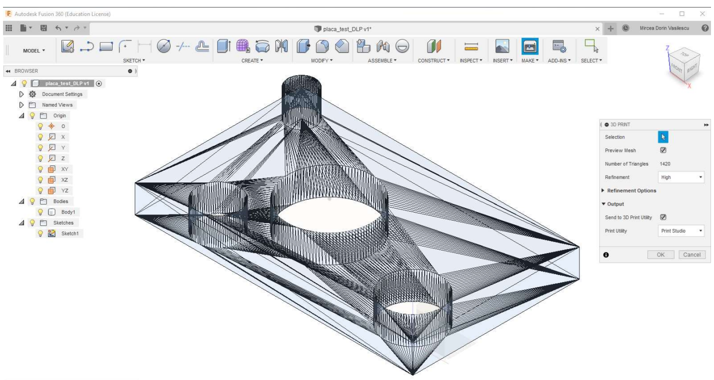


Figure 3. Design of the part use to export in PrintStudio for 3D printing

The domain of variation of quantities to be taken into study are centralized in table 1. It can be seen that they are specific to the type of resin that is used, as well as the specific features of the printer with which it carries out the process of 3D printing.

Table 1. Fixed parameter for DLP 3D printing and layer structure

Fixed parameters [1, 2]	usual in microns		UM
	min	max	
layer thicknesses	20	100	
resin thicknesses	8	16	DLP Wanhao Standard Black
resin hardening depth	0,1	mm	
resin expose	13	17	sec/50micron
resin base layer	120		sec
printer XY resolution	47		microns
printer Z resolution	1,25		microns
printer layer thicknesses	28	100	microns
printer print speed suggested	10	18	mm/hour

Resin-Printer Fixed parameters [3]	horizontal	vertical	UM
resin bending resistance	8,43	5,57	Mpa
resin stretch resistance	21,4	15,2	MPa
resin hardness	79,2	73,5	
resin layer expose time	6		sec/layer
resin bottom expose time	50		sec/layer

In Figure 3 it is possible to see the part disposed on the printed surface, and a layer image generated by the printer.

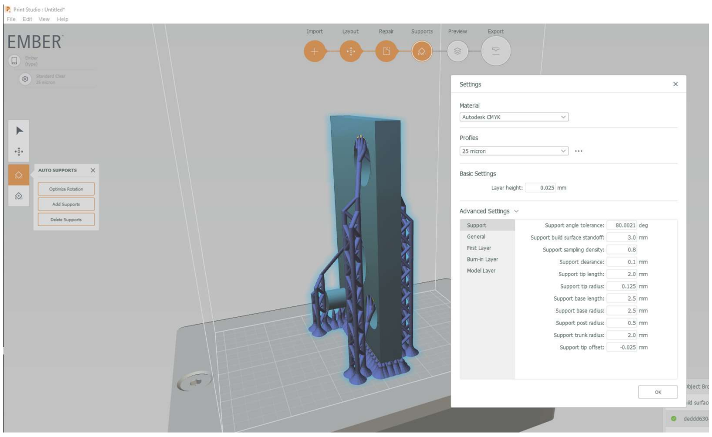


Figure 3. Orientated part for DLP printing and layer structure for 3D printed

The advantage of using this software is that it allows the execution and checking of the part structure as well as the optimization of the proposed guidelines be vertical supports for the realization of their generation the process of printing.

From the study of existing data from different researchers may come off the way you can change the values of the elements it is recommended to change the 3D printing process Table 3 [4, 5].

Table 2. Value for DLP 3D printing elements and layer structure, left from [4], right from [5]

	Value					UM
Layer in micron	0,025	0,05	0,05	0,025	0,05	micron
Normal expose time	18			16	15	sec
Off time	5,5	1	3	6,5	1	sec
Bottom expose	60	50	60	90	50	sec
Bottom layer	8	5	8	8	8	

Layer	0,025	micron
normal expose time	18	sec
Off time	5,5	sec
Bottom expose	60	sec
Bottom layer	8	

On the basis of the facts presented can build an experimental program to determine based on the values of the results obtained for input sizes measured Table 3 [3].

To be able to process more effective 3D printing parts considering that printed simultaneously on the surface, we will analyse the specific values that are required for generating parts, to achieve consolidated and reduce experimental costs.

Changed value was originally part position in relation to the printing surface while keeping the other parameters constant. Position was changed first to the Y axis Table 4 and then 5 X Table [1, 2].

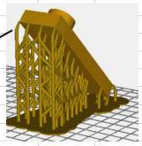
Table 3. Input parameter for experimental DLP 3D printing and layer structure

Input Parameter	+1		0	Recom	-1	UM
layer thicknesses	20	25	40	50	60	microns
resin expose				6		sec/50micron
resin base layer	60		90	50	120	sec
Normal expose time	13	18	15	8	18	sec
Off time	4,5		5,5	3	6,5	sec
Bottom expose	50	60	90	60	120	sec
Bottom layer	5	8	7	5	9	

Drawing value generated			Diameters		
Length	50	mm	Hole 1	8	mm
Width	30	mm	Hole 2	10	mm
Height	5	mm	Hole 3	15	mm
Height cilinder	5	mm	Cilinder	5	mm

Table 4. Output position Y parameter for experimental DLP 3D printing and layer structure

Output Parameter						
Experiment	1	2	3	4	5	UM
Pozition	Oriz	30	60	90	45	
Time	54/65	122/149	169/206	182/222	145/177	min
Layer	271	643	899	971	771	
Thickness	0,05	0,05	0,05	0,05	0,05	mm
Volume	4,2	4,6	4,3	4	5,1	ml



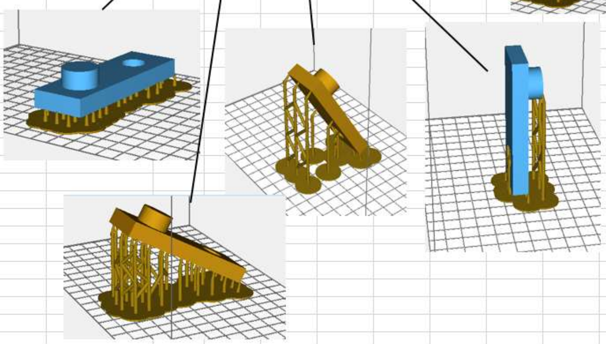
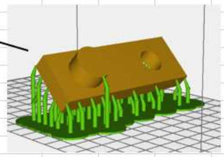
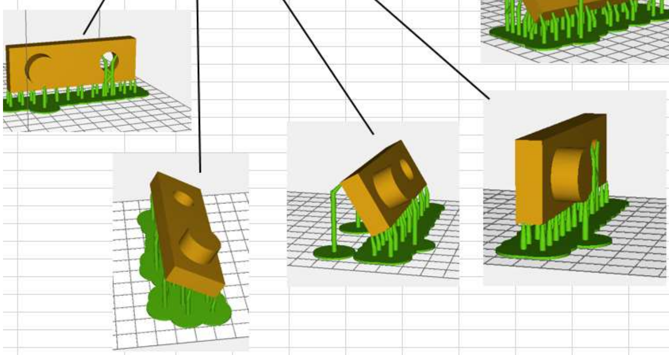


Table 5. Output position X parameter for experimental DLP 3D printing and layer structure

Output Parameter						
Experiment	1	2	3	4	5	UM
Pozition 90 X	Oriz	30	60	90	45	
Time	72/87	71/91	75/91	72/87	74/90	min
Layer	371	368	386	371	382	
Thickness	0,05	0,05	0,05	0,05	0,05	mm
Volume	4	4,3	4,3	4	4,7	ml





2. Comparison of the method of generating the part by 3D printing DLP with FDM method

In terms of the generation of the model taken into account it can be seen that the influence on material consumption and duration processing part has both the number of layers from the upper and lower respectively, and density the internal structure of Table 6.

A representation of the FDM method generated layer can be seen in Figure 4.

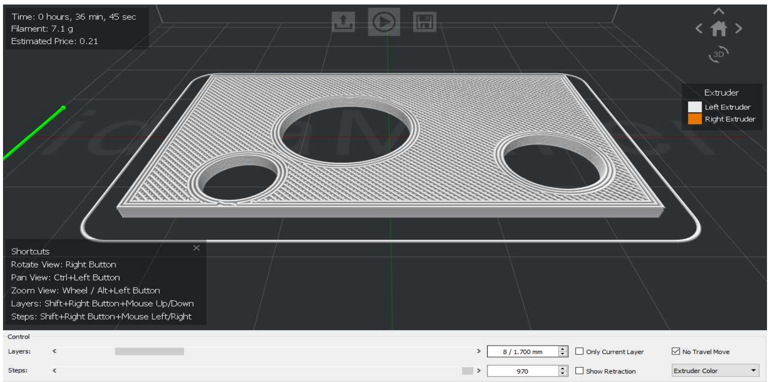


Figure 4. Layer structure for 3D printed FDM with 80% infill

Table 6. FDM 3D printing and layer structure

Top	Bottom	Infill	Time	Weight	Length	Layer
				gram	meter	
7	5	20	29 min 40 sec	5,5	1,84	50
5	3	20	26 min 24 sec	4,8	1,6	50
4	2	20	24 min 41 sec	4,4	1,48	50
3	2	20	23 min 51 sec	4,2	1,42	50
3	3	20	24 min 46 sec	4,4	1,48	50
2	2	20	23 min 3 sec	4,1	1,36	50
4	4	20	26 min 26 sec	4,8	1,6	50
4	4	40	30 min 13 sec	5,5	1,85	50
4	4	60	33 min 36 sec	6,3	2,11	50
4	4	80	36 min 45 sec	7,1	2,37	50

It can be seen that while the number of the upper and lower layers have an influence of 1.4 grams, the influence of the infill of the central area has an influence of 2.3 grams. On the quality of the surface it can be seen that the influence is less sensitive if we analyze the outer upper part for a larger number of 4 layers. It is also apparent that for a density of 40% can be obtained the same material consumption as in the case of the 7 layers of upper and lower 5.

From those shown can be seen that the generation of FDM is linear in time as we presented in the first chapter the generation DLP is on achievement of each layer by lighting point of the adjacent areas.

3. Analysis of the surface generating the part by 3D printing DLP with FDM method

To analyses the quality of optical surface has been used a microscope with magnification between 50 and 500 parts, Figure 5.

Pictures were taken of the surface with an increase of 70 or lower surface Figure 6 for the left side and the top on the right side. Both were made in the area of a hole in order to be able to visualize the layout of this area generated by printing 3D FDM. You can see both the shape relative to the lower circular but also upper-roundness. If the bottom surface quality is dependent on the quality of the substrate on which it prints at the top very much depends on print speed and thickness.

It was also analyzed and generating part of the edge. It can be seen rounding the edge in both areas generated, which depends on the specific speed limits perimeter layer generation who analyzed the case was 45 mm/sec. If the bottom quality sides is dependent on the quality of the substrate on which it prints at the top very much depends on print speed and thickness.

Figure 5. Microscope for analysis

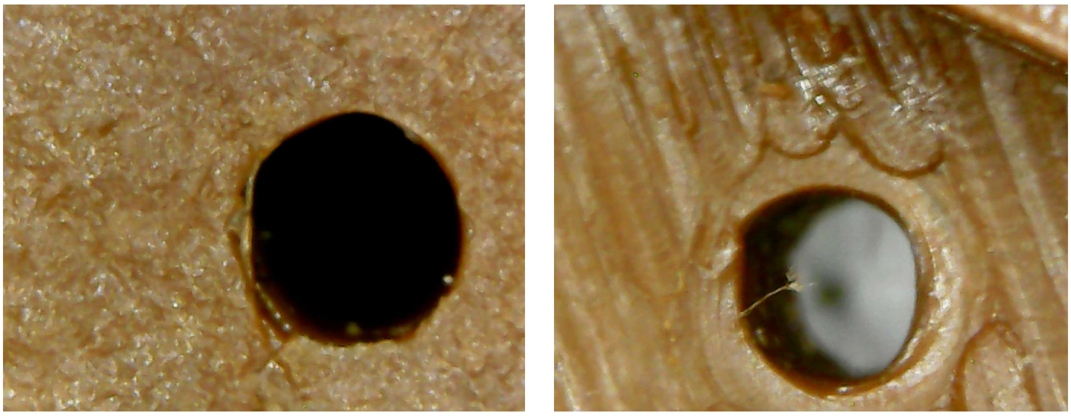


Figure 6. FDM part analysis hole left bottom, right top structure

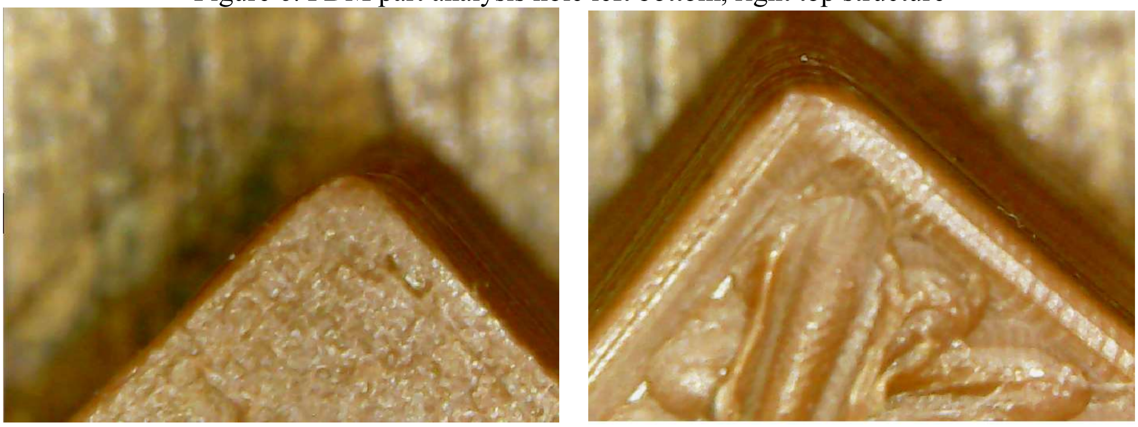


Figure 7. FDM part analysis comer left bottom, right top structure

For generated by DLP print technology can be seen from the same viewpoint and the elements taken into account and the same increase that the changes are not significant on the two areas for the items generated. The surface quality analysis was analyzed at the bottom so the side vent and side edge Figure 8. Surface quality analysis has been carried out to study the upper hole in the side of both, but also on the edge of Figure 9. The position of 3D printing it is horizontal.

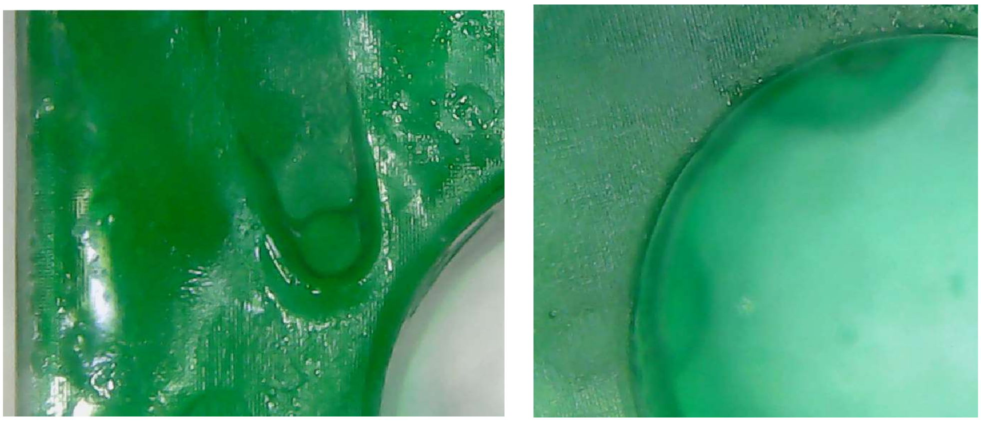


Figure 8. DLP part analysis hole left bottom, right top structure

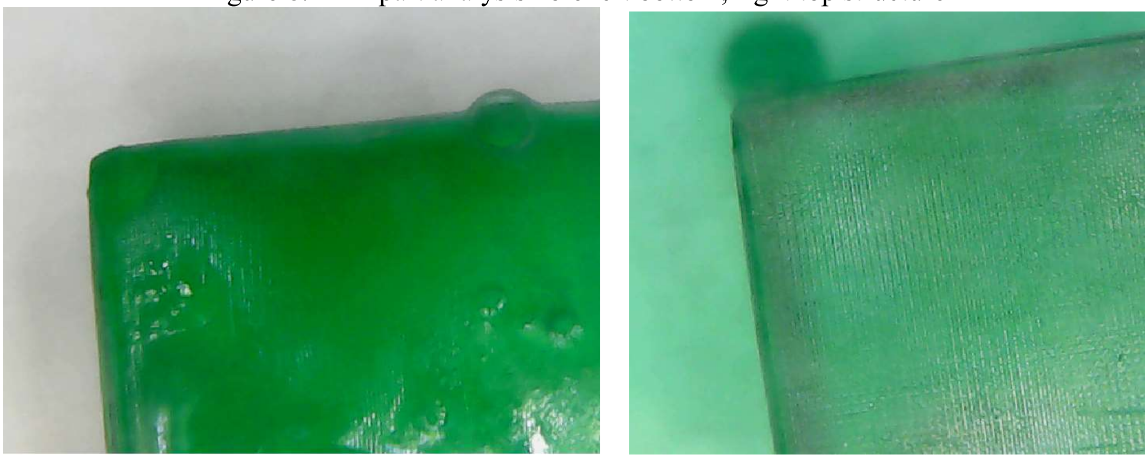


Figure 9. DLP part analysis comer left bottom, right top structure

4. Flat surface generated by 3D printing DLP method

Planar surfaces generation is important from several standpoints. Mention of these areas moving 3D printed elements with metallic or non-metallic surfaces that come in contact with other surfaces and ensures mechanical takeover requests the usual compression and last but not least areas transparent which provides visualization of how the different technological or experimental processes is in evolution.

Are important deviations from flatness and straight line and opacity from point of transparent volumes for different types of light or beams. In this study were addressed only the first two issues.

From these points of view you can see the quality of the surface which does not depend much on how inclination in the print, 3D and the deviation from a straight line is small or non-existent in the cases analyzed.

It should be borne in mind that generation process must be followed by a process of removing excess material from the surface and then a UV exposure parts generated. The process is time consuming but it can be done in parallel with the printing. Figure 10 presents the completion of 3D printing and the two aforementioned phases.

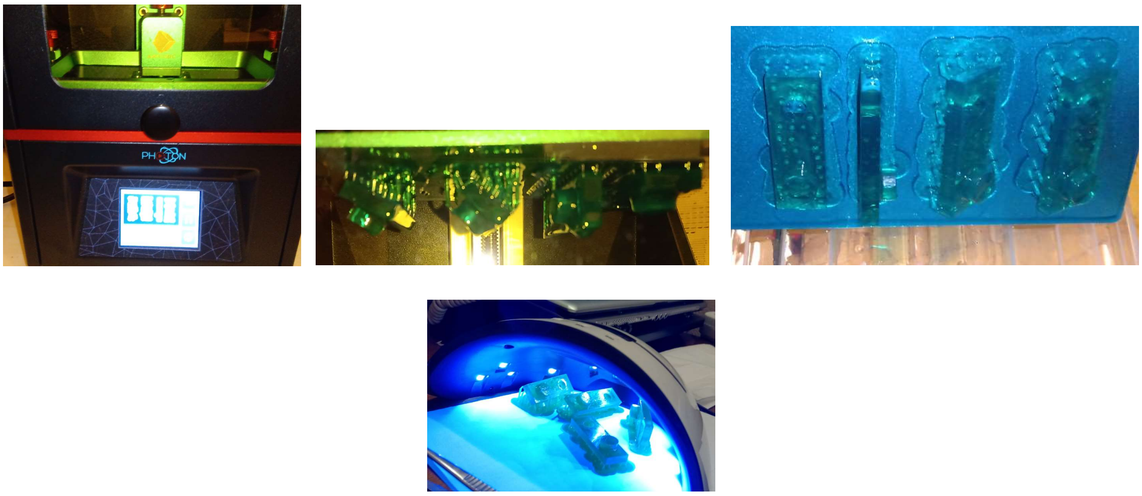


Figure 10. Faze of generation 3D printing parts

5. Conclusion of parts generated with DLP method

It can be seen that the generation of DLP is a printing process that takes place as the length of time faster than the FDM process printing.

At the same time from the standpoint of the forms generated it can be asserted that the precision is better for printing the DLP from the print FDM.

The comparative study is conducted if this works on both side of the marker and realization on the quality of the surfaces and volumes generated.

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