DETERMINATION OF DIMENSIONAL REGRESSION EQUATIONS FOR 3D DLP PRINTING

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ABSTRACT: In the paper, it is made a study to determinate the influences of different colour of resin in relation to the dimensional characteristics on the LCD photo polymerisation 3D printing process. In the first part are presented the element used to dimensional study and resins type and proprieties. In second part of the paper, it is possible to see the measurement methodology for dimension element and it is made the dimension measurement study and determinate the regression equations specific to each resins analysed. From the study, it is possible to see that the colour have an influence in direction of dimension in X and Y direction in horizontal or inclined position. The influence is greater in Y direction for different colour and lower in horizontal directing.
KEY WORDS: constructive dimension; air pollution, resin material, DLP printing

1. GENERAL CONSIDERATION CAD AND PRINTING METHODE

Determining how the linear dimensions of a geometric element in the technological field it is changed is a very important element. The importance is given both by the knowledge of how the desired nominal size will effective made, but also in order to be able to make the necessary corrections in the design phase. For this study, an experimental model was designed which was organised on the principle of determining linear dimensions on samples printed with different types of resins and at different inclinations of them. The process of printing with resin it is influenced by the aspects of polymerization of the material, but also by the orientation of the light beam in relation to the direction of printing and arrangement of the printed element. From the studies undertaken it is possible to observe that the orientation of the printed element it is possible to see that is positioned in one of the positions. For printing, a CAD model generated in FUSION 360 Educational [1] was used which was generated in the X-Y plane with the extrusion of the profile of the two vertical generation plans to a size of 5 mm. In longitudinal direction X value are from 25 to 80 mm and in transversal direction Y value are from 5 to 30 mm value Figure 1.

A ANYCUBIC PHOTON [2, 9] Figure 2 printer and several resin types from the same manufacturer that are recommended for the printing process were used to perform the 3D resin medium process Figure 3. The printing process was done at a layer thickness of 0.050 mm and with an exposure duration of the base marker and 50 seconds generation layers. The number of base layers was set to eight, and the type of supports set was of medium density with tapered structure in the support with item surface contact area.

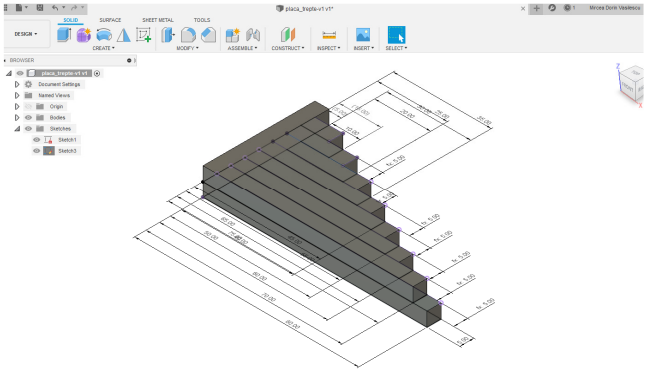

Figure 1. CAD item generated in FUSION 360

For the realization of the CAM program in the LED structure variant was used the program recommended by the manufacturer ANYCUBIC PHOTON Slicer [8, 10]. From a dimensional point of view, the dimensions were determined according to the two directions X the maximum length and Y the smaller length. The X direction are in horizontal position and Y are oriented at 15-degree angle from the horizontal position.

The measurement of the linear dimensions was made by placing the calliper in a support that allowed the positioning of the sample in the central area of printed frontal surface. The sample was moved linearly in a direction transverse to the measurement one in order to preserve the accuracy of the measurements and their repeatability. The linear dimension were determined with a digital calliper with the accuracy of 0.01 mm.

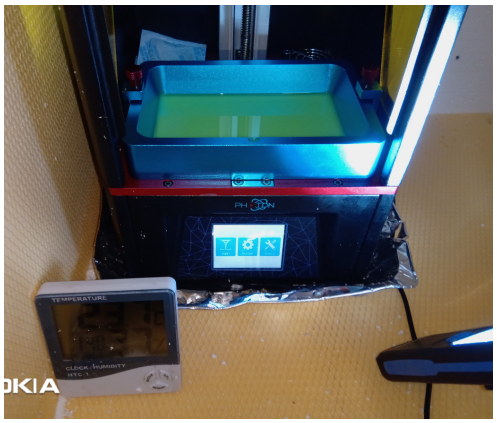

Figure 2. 3D printer ANYCUBIC PHOTON

Figure 3. Resin used for 3D printing item

2. RESULTS AND DISCUTION ON THE STUDY OF DIMENSIONAL GEOMETRY MADE WITH DLP 3D PRINTING PROCESS

A large image example is presented in Figure 2. In order to insert a large image you may use one column format. Singular printing of each item did the generation of the items. The under controlled environmental conditions as a temperature and humidity level it is used for printing. In Figure 4 it is possible to see the samples obtained from the printing process with the supporting structure [4-7].

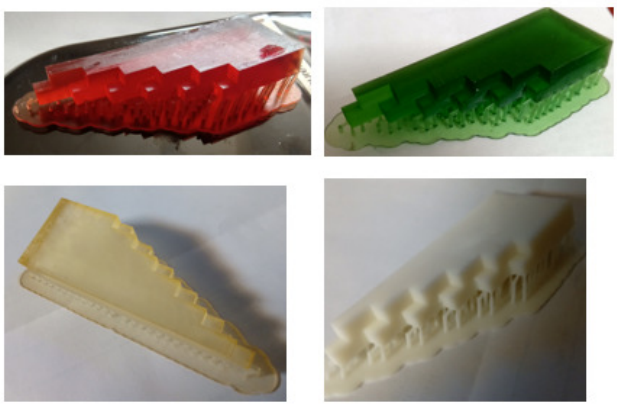

Figure 4. 3D printed item for dimensional study

2.1 Study of dimension for red semi-transparent resin

After measuring the dimension this are presented in Figure 5. In figure at the last two colons was calculated the deviation from normal value of the CAD item. In Figure 6 for X direction and Figure 7 for Y direction it is determined after plotting the extension equation deviation and for this item. In the same time, it is possible to observe the specific trends.

No	Nominal		Printed		Deviation	
	X in mm	Y in mm	X in mm	Y in mm	X in mm	Y in mm
1	80,00	30,00	83,61	31,08	3,61	1,08
2	75,00	25,00	78,37	26,05	3,37	1,05
3	70,00	20,00	73,20	20,79	3,20	0,79
4	65,00	15,00	67,95	15,72	2,95	0,72
5	60,00	10,00	62,91	10,44	2,91	0,44
6	55,00	5,00	57,68	5,26	2,68	0,26
7	50,00		52,54		2,54	
8	45,00		47,35		2,35	
9	40,00		42,22		2,22	
10	35,00		36,76		1,76	
11	30,00		31,62		1,62	
12	25,00		26,20		1,20	

Figure 5. Value for dimension in X and Y direction for red colour in 3D printing DLP type

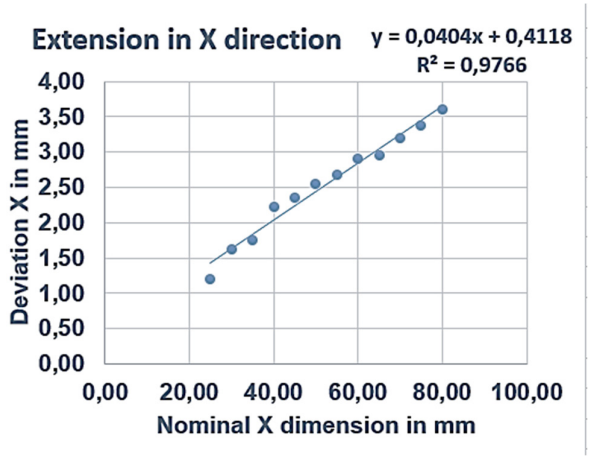

Figure 6. Dimension on X direction for part 3D printed DLP process red resin

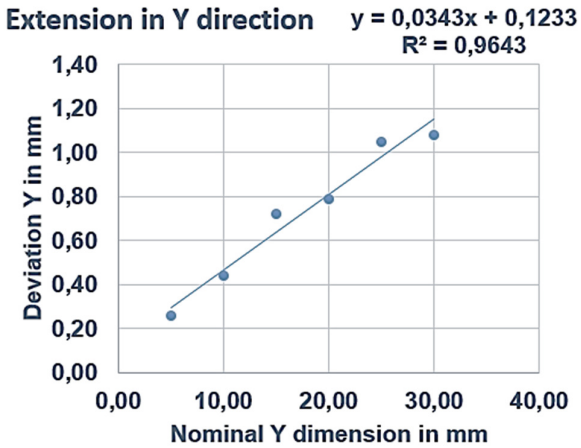

Figure 7. Dimension on X direction for part 3D printed DLP process red resin

It is possible to observe that for both directions the optimal regression equation is linear being greater than 95%. In addition, it is possible to observe that the deviation from the nominal value is smaller at an angle of inclination of 15 degrees with respect to the horizontal position.

2.2 Study of dimension for clear resin

After measuring the dimension this are presented in Figure 8. In figure at the last two colons was calculated the deviation from normal value of the CAD item. In Figure 9 for X direction and Figure 10 for Y direction it is determined after plotting the extension equation deviation and for this item. In the same time, it is possible to observe the specific trends.

No	Nominal		Printed		Deviation	
	X in mm	Y in mm	X in mm	Y in mm	X in mm	Y in mm
1	80,00	30,00	83,63	31,34	3,63	1,34
2	75,00	25,00	78,58	26,21	3,58	1,21
3	70,00	20,00	73,16	20,93	3,16	0,93
4	65,00	15,00	68,08	15,60	3,08	0,60
5	60,00	10,00	62,89	10,30	2,89	0,30
6	55,00	5,00	57,64	5,13	2,64	0,13
7	50,00		52,38		2,38	
8	45,00		47,18		2,18	
9	40,00		41,99		1,99	
10	35,00		36,75		1,75	
11	30,00		31,40		1,40	
12	25,00		26,14		1,14	

Figure 8. Value for dimension in X and Y direction for clear colour in 3D printing DLP type

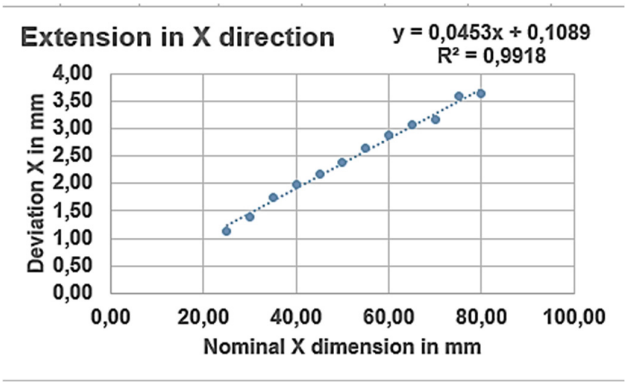

Figure 9. Dimension on X direction for part 3D printed DLP process clear resin

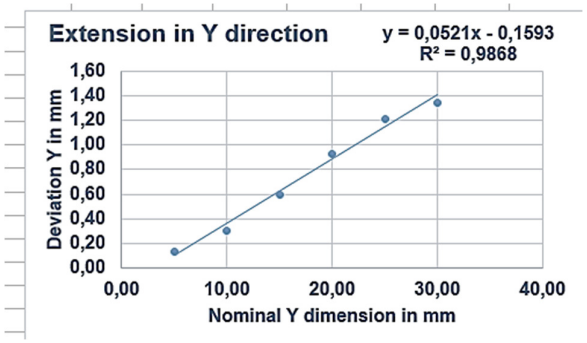

Figure 10. Dimension on Y direction for part 3D printed DLP process clear resin

It is possible to observe that for both directions the optimal regression equation is linear being greater than 95%. In addition, it is possible to observe that the deviation from the nominal value is smaller at an angle of inclination of 15 degrees with respect to the horizontal position.

2.3 Study of dimension for green resin [3]

After measuring the dimension this are presented in Figure 11. In figure at the last two colons was calculated the deviation from normal value of the CAD item. In Figure 12 for X direction and Figure 13 for Y direction it is determined after plotting the extension equation deviation and for this item. In the same time, it is possible to observe the specific trends.

No	Nominal		Printed		Deviation	
	X in mm	Y in mm	X in mm	Y in mm	X in mm	Y in mm
1	80,00	30,00	83,54	31,19	3,54	1,19
2	75,00	25,00	78,47	26,09	3,47	1,09
3	70,00	20,00	73,28	20,94	3,28	0,94
4	65,00	15,00	68,07	15,65	3,07	0,65
5	60,00	10,00	62,86	10,47	2,86	0,47
6	55,00	5,00	57,73	5,31	2,73	0,31
7	50,00		52,48		2,48	
8	45,00		47,30		2,30	
9	40,00		42,29		2,29	
10	35,00		36,98		1,98	
11	30,00		31,78		1,78	
12	25,00		26,28		1,28	

Figure 11. Value for dimension in X and Y direction for green colour in 3D printing DLP type

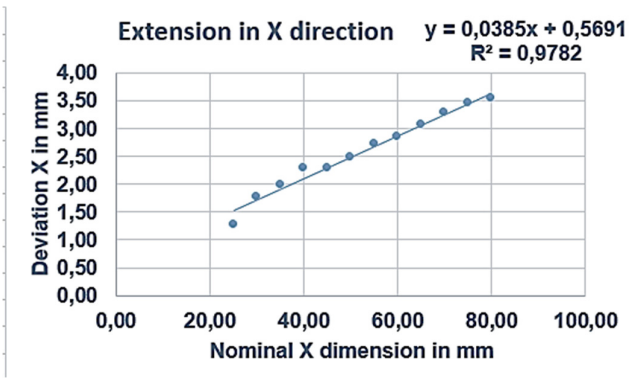

Figure 12. Dimension on X direction for part 3D printed DLP process green resin

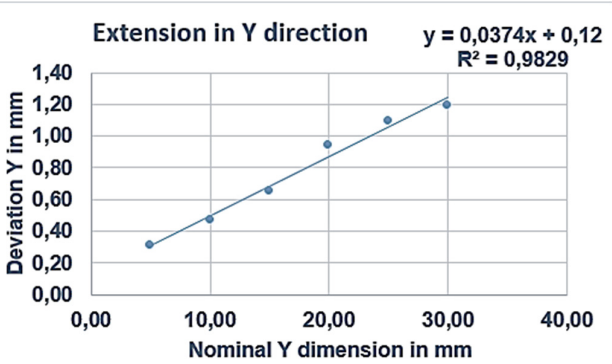

Figure 13. Dimension on Y direction for part 3D printed DLP process green resin

It is possible to observe that for both directions the optimal regression equation is linear being greater than 95%. In addition, it is possible to observe that the deviation from the nominal value is smaller at an angle of inclination of 15 degrees with respect to the horizontal position.

2.4 Study of dimension for white resin

After measuring the dimension this are presented in Figure 14. In figure at the last two colons was calculated the deviation from normal value of the CAD item. In Figure 15 for X direction and Figure 16 for Y direction it is determined after plotting the extension equation deviation and for this item. In the same time, it is possible to observe the specific trends.

No	Nominal		Printed		Deviation	
	X in mm	Y in mm	X in mm	Y in mm	X in mm	Y in mm
1	80,00	30,00	83,66	31,44	3,66	1,44
2	75,00	25,00	78,56	26,22	3,56	1,22
3	70,00	20,00	73,33	20,98	3,33	0,98
4	65,00	15,00	68,14	15,71	3,14	0,71
5	60,00	10,00	62,99	10,47	2,99	0,47
6	55,00	5,00	57,73	5,27	2,73	0,27
7	50,00		52,57		2,57	
8	45,00		47,34		2,34	
9	40,00		42,17		2,17	
10	35,00		36,75		1,75	
11	30,00		31,69		1,69	
12	25,00		26,31		1,31	

Figure 14. Value for dimension in X and Y direction for white colour in 3D printing DLP type

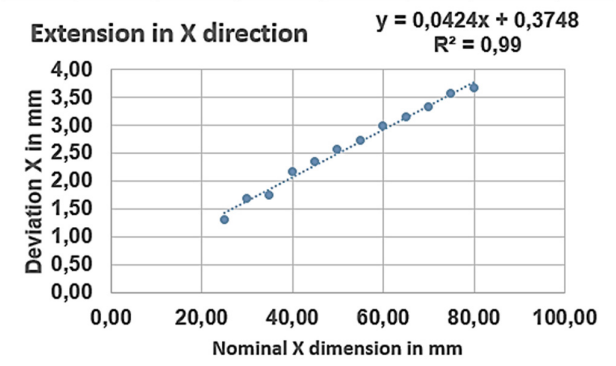

Figure 15. Dimension on X direction for part 3d printed DLP process white resin

It is possible to observe that for both directions the optimal regression equation is linear being greater than 95%. In addition, it is possible to observe that the deviation from the nominal value is smaller at an angle of inclination of 15 degrees with respect to the horizontal position.

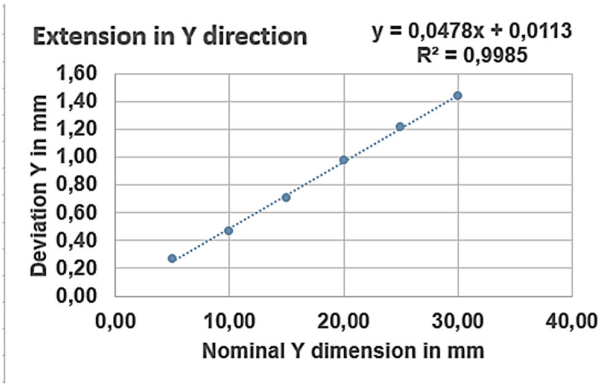

Figure 16. Dimension on Y direction for part 3D printed DLP process white resin

2.5 Comparative study of dimension in X an Y direction for used resin to printing

A comparative study between the four types of resins was undertaken from the values resulting from the experiment. From the comparative study, it is possible to see in Figure 17 for X deviation and Figure 18 for Y deviation that are relevant deviation on the degree of printing for different colour of material.

In X direction that is the horizontal direction it is smaller in function of colour because the printing is in the horizontal plane. In Y direction because the printing it is made at 15 degree deviation in rapport of the horizontal plane for printing the difference are greater.

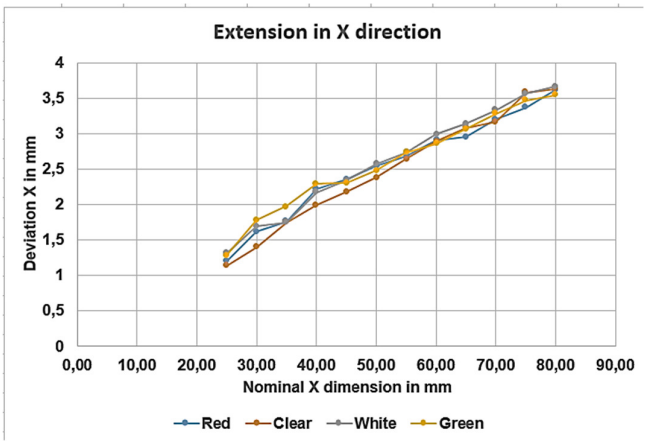

Figure 17. Comparative deviation for X dimension

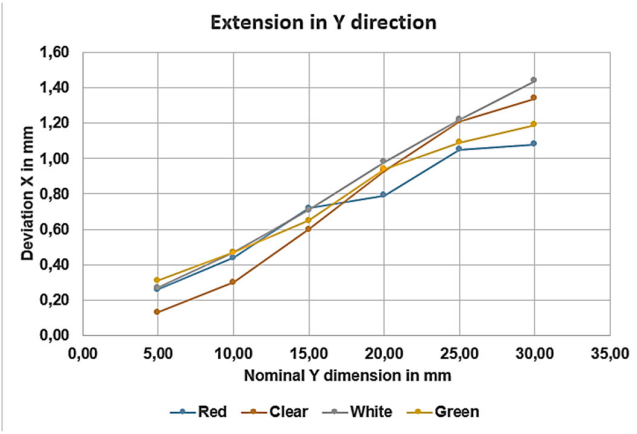

Figure 18. Comparative deviation for Y direction

It is possible to observe that from the comparative study that if after direction X horizontal regression lines show a similar upward trend regardless of the type of resin in the direction Y the data change.

The principal causes is the different reflection and refraction light for different colour of material. The greater value is for white colour and the smaller for red colour in Y direction.

3. CONCLUSION

The present study intended to be a beginning of research on the plan part generation with different colour in 3D printing process, which is possible to be used for pneumatic/hydraulic system. The interest are for constructive solution for water jet cutting installation and abrasive water jet cutting installation.

It is possible to see that in rapport of the deviation of nominal dimension for part generated the colour are influence in rapport of the degree of inclination in rapport with the horizontal printing surface.

4. ACKNOWLEDGEMENTS

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