Constructiv and Technological Consideration on the Generation of Gear Made by the DLP 3D-Printed Methode

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The aim of the work is conduct to highlight how the technological parameters has influence of 3D printed DLP on the generation of wheel, made from resin type material. In the first part of the paper is presents how to generate in terms of dimensional aspects specific design cylindrical gears, conical and worm gear. Generating elements intended to reduce the cost of manufacturing of these elements. Also are achieve the specific components of this work are put to test with a laboratory test stand which is presented in the paper in the third part of the paper. The tested gears generated by 3D-printed technique made with 3D printed with FDM or DLP technique. After the constructive aspects, proceed to the identification of conserved quantities, which have an impact both in terms of mechanical strength, but his cinematic, in order to achieve a product with kinematic features and good functional domain specific had in mind. The next part is carried out an analysis of the layers are generated using the DLP and FDM method using an optical microscope with magnification up to 500 times, specially adapted in order to achieve both visualization and measurement of specific elements. In the end part, it will highlight the main issues and the specific recommendations made to obtain such constructive mechanical elements.

Keywords: 3D printing; fabrication parts; generated gear, DLP material, DLP printing

Design and implementation of components for mechanical and electromechanical command type of wheels that have a structure composed of wheel type is an important component of the transformation processes but also on order. From a constructive point of view, there are several types of wheels. The most common are the wheels and gear wheels, followed by the trapezoidal belt [1].

We will study how the gears on the principle of generating the CAD generation and after that on an FDM (Fused Deposition Modelling) [2-5] and after this on a DLP (Digital Light Processing) made in optimum conditions. For the first case, are generated a double pinion with vertical teeth. In figure 1, it can see the wheel generated CAD principle consist of a pinion and a great rate of generated of the profile.

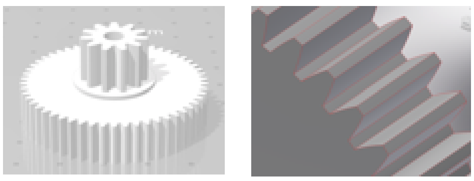
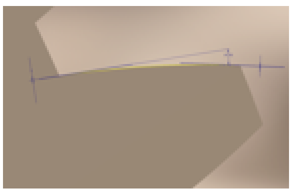

FIg. 1. Wheel geometry and evolventei in flank made in CAD

The generation on the principle of 3D printed by FDM structure is one composed of three layers lower minimum and the same upper and three-layer perimeter so as you can see in figure 2. To generate the inner part is a type structure with 40% density minimum in order to have a durable structure, but also with good properties of requests but also generate involute gear profile on submission of material [6].

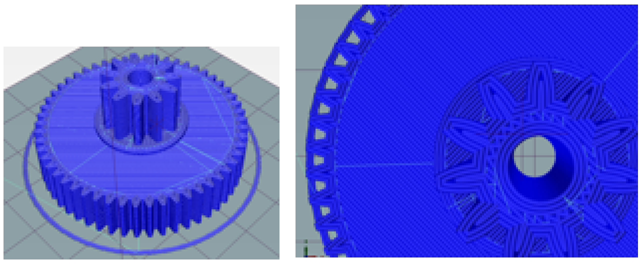

Fig. 2.Wheel geometry and involute flank by FDM printing

The profile generation side is very accurate on the programme to generate teeth. The wheel profile as can be seen in figure 3 is generated by merging the four points on the flank of the first of which is generated from the base of the tooth and the second at the tip of the tooth for a small module.

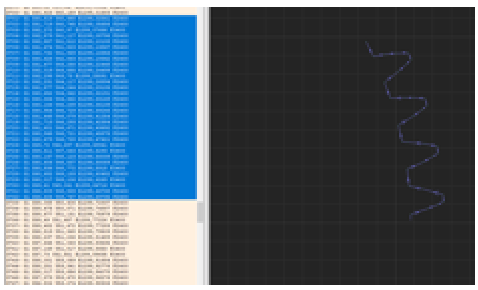

Fig. 3.The program GCode to flank involute wheel

It possible to seen that the small number of points to change the angle of teeth is smaller and higher (6 point) for how it grows no matter what would be the kind of program that makes command line program generation figure 4. The generation program made with RepetierHost. In figure 5, it is possible to see the program generated with IdeaMaker.

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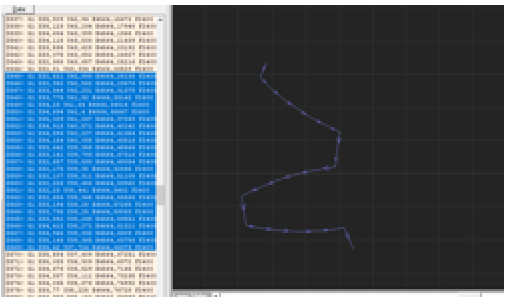

Fig. 4.The program GCode to flank involute wheel for big module

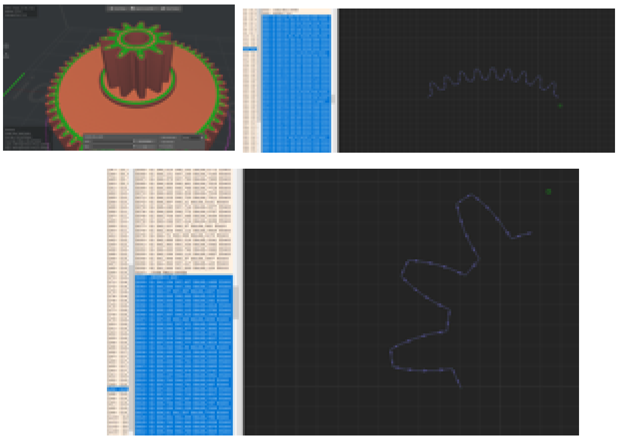

Fig. 5.The program GCode to flank involute wheel with IdeaMaker

At the basis of this study, it possible to seen that the made wheel profile on FDM is less precise in rapport with generating with CAD. Due to this reason, but also to be able to generate gears in small series we switched the generation of the gears on the realization of principle of wheel DLP thanks mainly to generate relatively fast on the screen and not on that of the trace lines.

The first aspect is that of accuracy of profile generation. If it proposed that, the generation area is 115 mm in length on 65 mm wide and accurate 47-micron size flat. It is possible to view that the generation is more accurate for DLP 3D printed part. The number of points being from 42 points (1.925 mm / 0.047 mm) for small module of the wheel and 62 points (3.010 mm / 0.047 mm) for big wheel module. In figure 6, we can see the wheel gear, which is subject to the generation process.

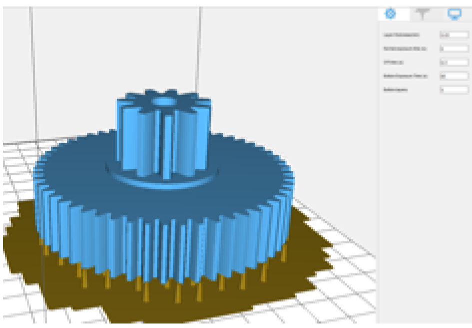

Fig. 6.Gear generated with DLP for 3D printed part

For generation are used bottom layer and supports. The generated time is 1 h and 50 min with 511 layers and 18.1 millilitres of resin and 0.05 mm for layer height. From the analysis carried out can be seen much better quality wheel gears, achieved through the generation of DLP.

Considerations on the generation of Gears for 3D printing

In terms of 3D printed gears, from the point of view of optimal orientation may take into account the recommendations from the literature that most of them directed towards the direction of minimum horizontal surface. To determine the manner in which change the dimensions generated by printing function of guidance is realized a gear blank figure 7. It made more orientation for gear blank so that we can determine the influences of dimension in relation to the guideline for a cylindrical element figure 8, dimensional data, and generating table 1.

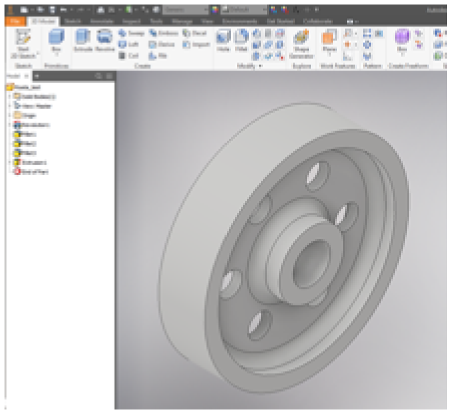

Fig. 7.Blank gear CAD generated

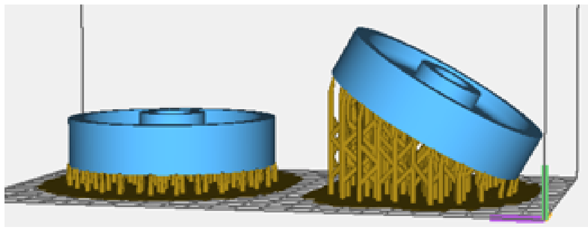

Fig. 8.Blank gear oriented horizontal left, 30 grad right to study the printing dimension

A first important observation is that at large angles of inclination is affected area will generate the default wheel teeth and teeth gears figure 9. From checking the items generated by 3D DLP printing is found the existence of errors of generating type isolated points where the slope at 60 degrees.

Table 1
BLANK GEAR ORIENTATION FOR 3D DLP PRINTING

Output Parameter						
Experiment	1	2	3	4	5	UM
Pozition	Oriz	30	45	60	90	grd
Time	69	145	177	198	202	min
Layer	311	683	828	931	951	-
Thickness	0,05	0,05	0,05	0,05	0,05	mm
Volume	8,9	10,1	11,6	8,8	8,2	ml
	146		202			min
	19		28,2			ml

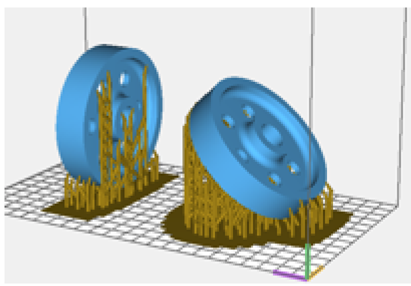

Fig. 9. Blank gear oriented vertical left, 45 grad right to study the printing dimension

As result of these observations, we will generate the wheel only with small angles of inclination especially due to the deformation produced by points of contact with the surface of the generated element supports.

Considerations on the creation of the GEARS through DLP 3D printing

In order to verify the conclusions previously assumed we generate wheel gear in three positions, namely horizontal, inclined at 30 degrees at top position with 2 h and 40 min time of printing and 755 layers with 19.0 millilitre of resin figure 10. At bottom with 45 and 90 degrees at bottom with 3 h and 28 min time of printing and 983 layers with 38.9 millilitre of resin figure 10.

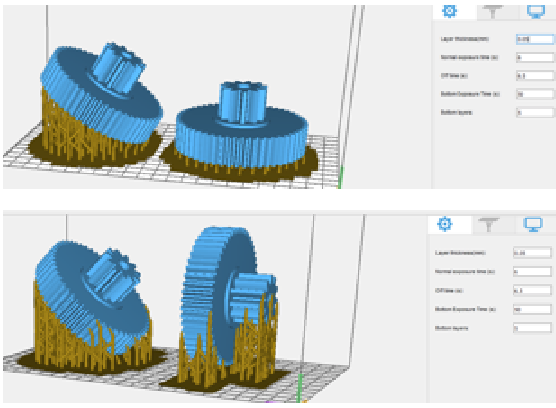

Fig. 10.Gears DLP printing at horizontal, 30 at top and 45, 90 degrees inclined at bottom

After printing the blank wheels and gears, they undergo a process of cleaning excess coating material in a pan with a medium type alcohol izopropylowy figure 11.

Fig. 11.Cleaning in alcohol

After that it is washing with distilled water will be subject to a process of curing ultraviolet wave for 30 min or in the Sun.

Part and Gear generated with DLP 3D PRINTING

An Anycubiq [7] printer used for printing. In (fig. 12) presented one of the generated part in different position.

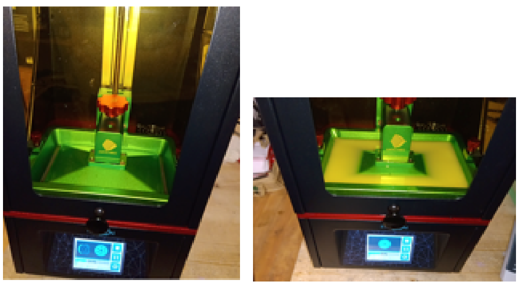

Fig. 12.Anycubic printer with blank left and gear right generated

We will look at the aspects of both dimensional control and inspect the blank gear and generated gear by DLP 3D printing. Part of the measurement made after removing items support highlights. There were parallel measurements of gravity and results compared with values obtained from slice part with the value after printing table 2. For generating blank gear are used an ANYCUBIC resin with setting for green colour [8, 9] and for gear WANYAN resin [8, 9] table 2.

Table 2

RESIN SETTING FOR DLP 3D PRINTING

Input Parameter	Value								UM
layer thicknesses	20	40	50	50	70	80	20	50	microns
resin expose	7,5	12	8	10	12	16	12	15	sec
Off time	1,5	3	1	1	1	3	1	1	sec
Bottom expose	40	80	50	50	55	70	40	50	sec
Bottom layer	8	5	8	8	8	4	8	8	
Type	Anycubic Green						Wanyan White		

After printing 3D figure 13 for blank gear, which have with, supports 13.6 g and out supports 9.1 g. Percent loss 49.45%. Larger loss due to the geometry of the print surface from the bench support plate.

Fig. 13.Blank gear oriented horizontal printed left with supports and right out supports

In figure 14 is gear printed which have with, supports 26.5 g and out supports 21.5 g. Percent loss 23.26%.

After that are both parts are optical visualization with optical zoom camera with 50-500 times both on edge and on the surface figure 15 for blank gear and figure 16 for gear for denture.

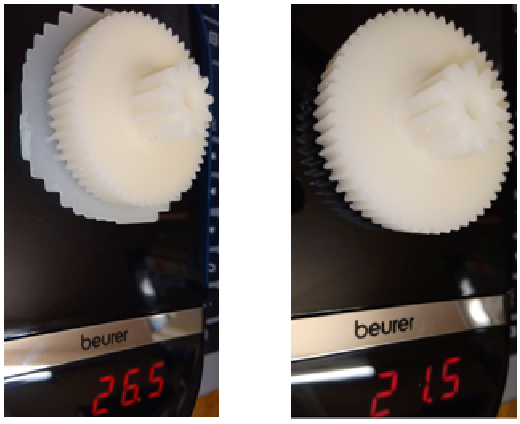

Fig. 14. Gear oriented horizontal printed left with supports and right out supports

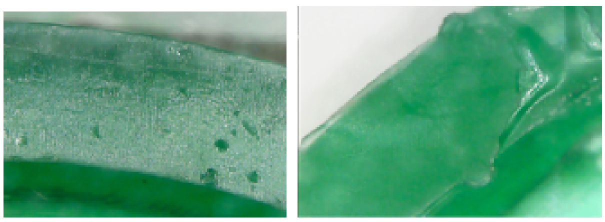

Fig. 15. Blank gear oriented horizontal top surface-edge left and surface-edge bottom right

From the analysis made it shows that have a diameter dilation of values of 3 to 5%. Therefore, if we achieve a decrease of values through scaling with decreasing 4% we get on the correct odds.

If we achieve the same study after drop-down direction, observed that different dilation as beach layout of percentage deviation. Due to this fact will recommend using the same decrease as diametrically.

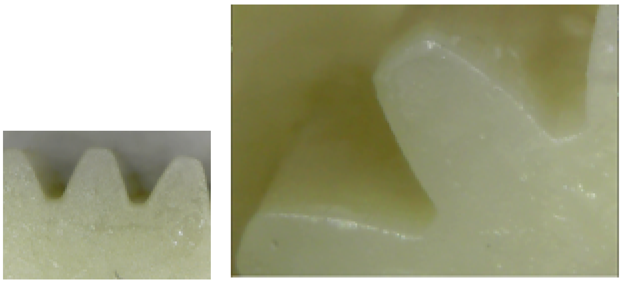

Fig. 16. Gear oriented horizontal printed small dent left and big dent right

Both parts checked by dimensional with digital calliper table 3 for blank and table 4 for gear.

Table 3

DIMENSIONAL VALUE FOR BLANK HORIZONTAL DLP 3D PRINTING

Tipe	Design	Made	Dev.%	UM	Obs.
Height Top	10,00	9,68	-3,20%	mm	Top suports
Height Base	12,00	12,33	2,75%	mm	
Height middle	4,00	4,03	0,75%	mm	
Hole inner	5,00	5,01	0,20%	mm	
Hole middle	8,00	8,27	3,37%	mm	
Diam Output	44,00	46,02	4,59%	mm	
Diam middle 2	38,00	39,51	3,97%	mm	
Diam middle 1	14,00	14,73	5,21%	mm	

Table 4

DIMENSIONAL VALUE FOR GEAR DLP 3D PRINTING

Tipe	Design	Made	Dev.%	UM	Obs.
Diam Output 1	45,62	47,74	4,65%	mm	
Diam Output 2	16,25	17,17	5,66%	mm	
Diam middle	20,00	21,23	6,15%	mm	
Height Top	22,00	22,20	0,91%	mm	
Height Base	10,00	11,04	10,40%	mm	
Height middle	11,00	11,44	4,00%	mm	
Hole inner	5,00	5,03	0,60%	mm	

From technological point of view, there are the following recommendations in order to make the double gears, which related mainly to specific elements of editing, and functional. Central hole processed through an adjustable reamer in order to obtain the desired hole.

The front part will support is printing shall be greater than 1 mm and will be processed if desired an equal width. It can, however, be processed through rectifying inclined 30 degrees right flank to ward off any deformation on the surface of the original print figure 17.

If we compare the resulting values of the program reported the amount of resin used, and quantities calculated it could see that there are differences. In the first place does not refer to loss of material through the supporting elements. Secondly, the value determined by measurement for parts and generation program differences can be observed in table 5.

Table 5

VALUE FOR BLANK GEAR DLP 3D PRINTING

Tipe	Calculate		Made		Dev.%	Obs.
	Value	Mass	With Suports	Part		
Horizontal	8,9	9,97	13,60	9,10	-8,73%	
30 degree	10,1	11,31	16,20	8,70	-23,08%	
UM	ml	gram	gram	gram		
		Density	1,12	gr/cm3		

Fig. 17. Blank gear oriented 30% printed extract from printer

Fig. 18. Blank gear oriented 30% printed mass

Table 6 shows the standard deviations calculated for model gear dimensions.

Table 6

DIMENSIONAL VALUE FOR BLANK 30% DLP 3D PRINTING

Tipe	Design	Made	Dev.%	UM	Obs.
Height Top	10,00	10,41	4,10%	mm	Top suports
Height Base	12,00	12,38	3,17%	mm	
Height middle	4,00	4,15	3,75%	mm	
Hole inner	5,00	5,04	0,80%	mm	
Hole middle	8,00	8,11	1,37%	mm	
Diam Output	44,00	45,88	4,27%	mm	
Diam middle 2	38,00	39,41	3,71%	mm	
Diam middle 1	14,00	14,86	6,14%	mm	

From the comparison of data it appears that, the deviation in relation to the projected values for inclined 30% to horizontal position is not very big. If we consider the applications that appear in the print it can concluded that it is appropriate to use a small inclination angle to reduce vibrational effects.

Conclusions

The present study are conducted to determine the specific realisation aspects of the gear by DLP 3D printing method, but also to check and correlate the data of the soft at the achievement of technological parts serrated.

Through work were addressed both aspects of implementation practice of the gears, as well as those related to differences in the calculate of the programs to generate layers for generating gears compared with real ones resulting from the manufacturing process effectively

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References

1.PRODAN, D., BUCURESTEANU, A., MOTOMANCEA, A., Construction of Plastic Parts on CNC Engraving Machines and 3D Printers, Mat. Plast., **55**, no.1, 2018, p.75-78,

2.VASILESCU, M.D., IONEL, I., 3D printer FABLAB for students at Politehnica University Timisoara, Advanced Learning Technologies (ICALT), 2017 IEEE 17th International Conference on Advanced Learning Technologies (ICALT), IEEE Xplore, SCOPUS , 2161-377X, 978-1-5386-3870-5, 512-513 pag, DOI 10.1109/ICALT.2017.106, Conference Proceeding (2019)
3.RAPA, M., DARIE NITA, R.N., VASILE, C., Influence of Plasticizers Over Some Physico-chemical Properties of PLA, Mat. Plast., **54**, no.1, 2017, p, 73-78
4.PASCU, N.E., ARION, A.F., DOBRESCU, T., CARUTASU, N.L., Fused Deposition Modeling Design Rules for Plastics, Mat Plast. **52**, no.2, 2015, p. 141- 143
5.POPESCU, A., ENCIU, G., DOBRESCU, T., PASCU, N. E., Experimental Research Using the 3D Printing Technology with Plastic Materials for Prehension Systems Jaws, Mat Plast., **55**, no.1, 2018, p.20-23
6.VASILESCU, M.D., FLESER, T., Influence of Technological Parametrs on the Dimesion of Gear Parts Generated with PLA Matherial by FDM 3D Printing, Mat Plast., **55**, no.2, 2018, p. 247 -251
7.*** -https://all3dp.com/1/anycubic-photon-3d-printer-review/, (2019)
8.***https://wiki.bryscus.com/display/3DP/Anycubic+Photon+Settings, (2019)
9.***https://docs.google.com/spreadsheets/d/1crvzMnt_8NJXAsABinoIhcOjE8l3h7s0L82Zlh1vkL8/edit#gid=0, (2019)
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