Influence of Technological Parametrs on the Dimension of Threaded Parts Generated with PLA Matherial by FDM 3D Printing

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In this research are establish the technology of 3D printable parts by the principle of FDM 3D printed for threaded made by PLA, ABS, Nylon or PETG. In the paper are present first the dimensional generation and specific aspects that need to be considered to produce threaded with internal teeth of the metric, round or trapezoidal type. Generating the threaded appeared as a necessity for the reconditioning or made of the components of the processing machines made both in the process of elaboration of the bachelor's and the laboratory works, with reduced energy resource consumption and low pollution as low as possible. After the construction, it is identify the dimension that have implications for both mechanical and kinematic resistance to make a product with good cinematic and functional characteristics. After that are made an analysis of the layers generated, both from the computer simulation and from the point of view of the analysis of layers physically generated for a threaded with internal teeth. At the end are presented which are necessary for operations to obtain a product with good features starting from two types of thread generated 8x2 and 10x2 moments.

Keywords: 3D printing; fabrication parts; dimension threaded, PLA material, FDM printing

In the moving system are components that have a structure composed by threaded and rigid structure for assembling construction [1, 2]. The generation of the thread is a complex and relatively difficult process. Part of this process is presented in (fig. 1.). The generation principle is specific to each type of the generation program. On the left side is the variant for generation in CATIA or INVENTOR where we generate a trapezoidal coil that it is made by roto translation process of generating of the thread. In FUSION 360 [3] the generation is carried out using a direct realization module that allows the principle to be obtained on the actual completion of a specific spiral library.

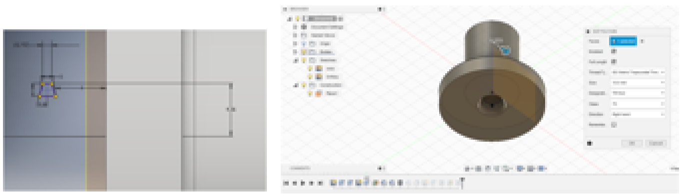

Fig. 1. Geometry conventional threaded to be made, left INVENTOR solution, right FUSION 360 solution

From a constructive point (table 1) of view most threaded components are made with two or more parts, which are mounted with fixing elements, centring and positioning relative one in relation to the other. This makes in terms of manufacturing costs to be relatively high, due to the precision necessary for installation.

Table 1
PART ROUND THREADED MADE

Diametru	Pas	D1	D2=d2	D4	ac	H1	H4=h3	z	d3
10,00	2,00	8,00	9,00	10,50	0,25	1,00	1,25	0,50	7,50
8,00	2,00	6,00	7,00	8,50	0,25	1,00	1,25	0,50	5,50
8	1,5	6,50	7,25	8,50	0,25	0,75	1,00	0,38	6,00

In order to achieve and mount nut a composite system made from a single part is conceived, as can be seen in (fig. 2.). The marker has both the fastening part on the motion element as well as the positioning and adjustment part of the mechanical lost motion.

In figure 2 was conducted the generation of the part using program INVENTOR [4] at which the thread was made by trapezoidal type for that is in the left part and the second is by round type in the right part. Note that the principle is the same, namely to make first the hole in the part in which you have conducted the element and then threading will be achieved by generating in a plane thread coaxial with the hole axis and perpendicular to the circular part the hole. From these it can see that we use to effective generation and not visual rather than imposed by 3D-generation programs by type CATIA, INVENTOR, Solid Work.

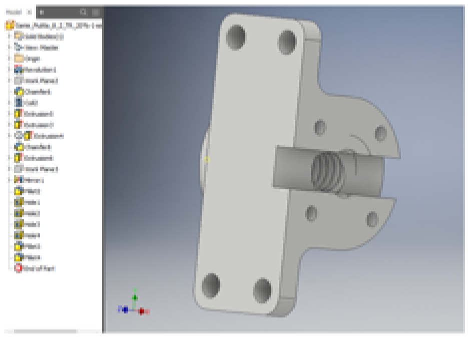

Fig. 2.Geometry 3D printed threaded by made

From the areas in which such components with maximum economic efficiency can be used, we considered:

-the repairing components made of metallic or non-metallic materials, in which the mechanical stresses are reduced or have average values

-the generated new parts at which the mechanical stresses are reduced or have average values.

From both the experimental and the specialized literature, we can conclude that there are a few materials that can be used successfully to achieve that condition. In this study are determinate the technological efficiency for the implementation of PLA, ABS and PETG materials for the making of 3D toothed parts by FDD (Fused Deposition Modelling) [5-7] technology, as well as the realization of

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components under the imposed conditions using materials and recyclable technologies that pollute less the workspace.

Considerations on the generation of threaded with 3D printing

Generating 3D printed parts of type with thread is a relatively difficult process. This is due to both its structure and mode of made it. In order to achieve effective printing you must first made the file of the item type to stl generated be checked if there are no problems to generate its structure from the point of view of electronic generation. Exist in the literature recommendations first this part generated to be transformed into a solid structure and after that to undergo the process of generating triangular structure specific to the generation of stl file [6-8]. The advantage of using the program to generate Fusion 360 is that it has and how to generate the component for 3D printing so the default component verification be carried out and completed.

In (fig. 3) shows the generated element Fusion 360 which it is possible to observe the complex form of it which includes the mesh structure of the part in which there are 24024 triangles.

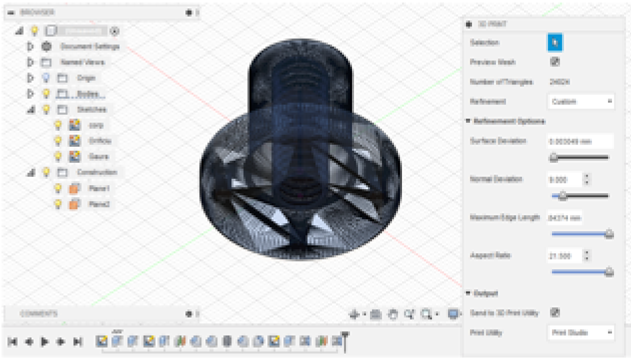

Fig. 3. Mesh part round threaded

Also, in (fig. 4) [9] is present the part in which it is possible to see that it is not problems of the structure generated.

After this check (fig. 5) it will proceed to the realization of specific support elements on the areas that they are required. If the part, it is positioned with the vertical position of the hole is not necessary for this to put support. But if it is positioned with the axis in the horizontal axis of the hole, the view on the right side shall be necessary to put support elements. This support elements should help to make the correct position of the structure.

The supporting elements can be linear as well as can be seen in (fig. 6) which are generated with [10]. We also considered this case to be able to make a practical comparison between the elements that are physically generated.

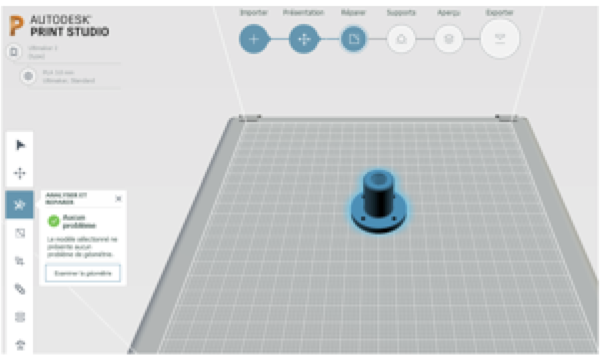

Fig. 4.Normal part round treaded in Print Studio

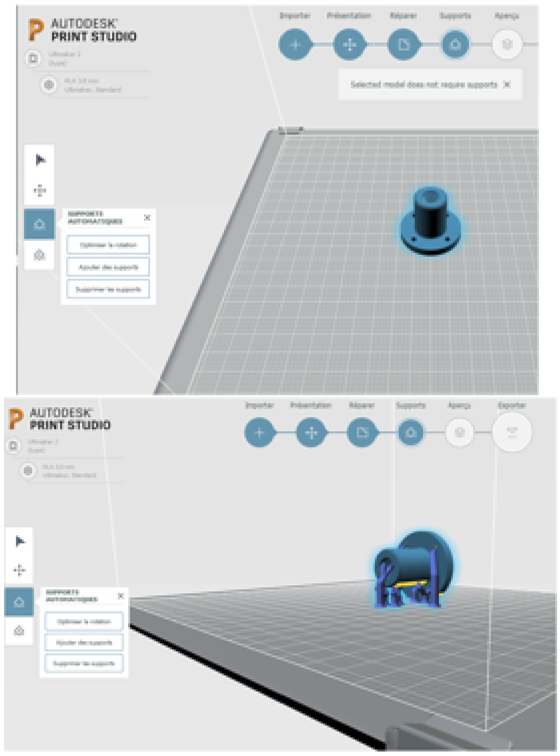

Fig. 5. Supports for 3D printed part in Print Studio top vertical generation 0 supports, bottom horizontal generation cylindrical supports

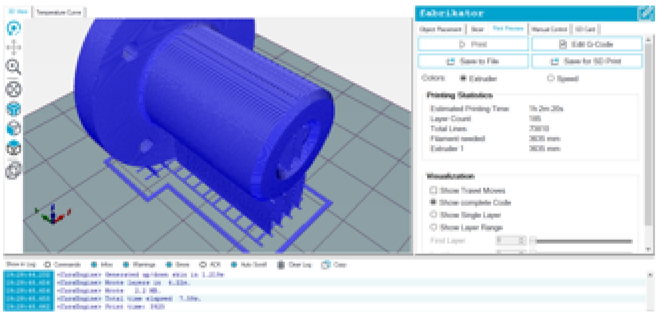

Fig. 6..Linear supports for 3D printed part in Repetier Hos

For the case of the completed piece we will achieve the positioning of the part on the two previously mentioned positions in order to make a more eloquent comparison between the actual realization modes (fig. 7).

On the up side is the vertical axis, while on the down side with the horizontal axis.

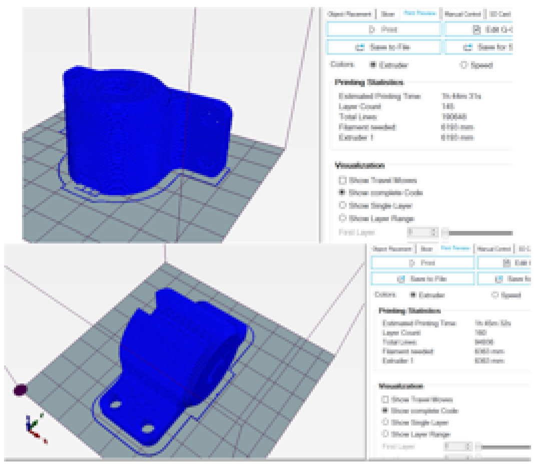

Fig. 7.Supports for 3D printed part in Repetier Host top vertical generation, bottom horizontal generation

At the same time the horizontal position ensures a better generation of the threaded surface than the vertical one as can be seen from (fig. 8.). On the left side is the horizontal axis generated with Repetier Host (Cura), while on the right side with the vertical axis.

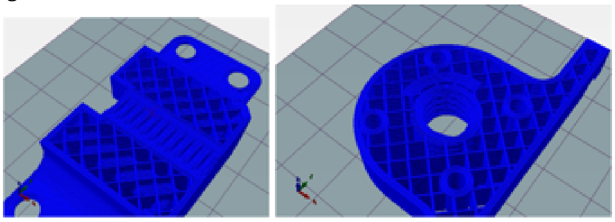

Fig. 8.Profile of threaded 3d printed Repetier Host left horizontal generation, right vertical generation

In (fig. 9) it can see the positioning of the circular supports for the optimum solution vertical axis generated with Print Studio of the hole to the up and the horizontal axis on the down.

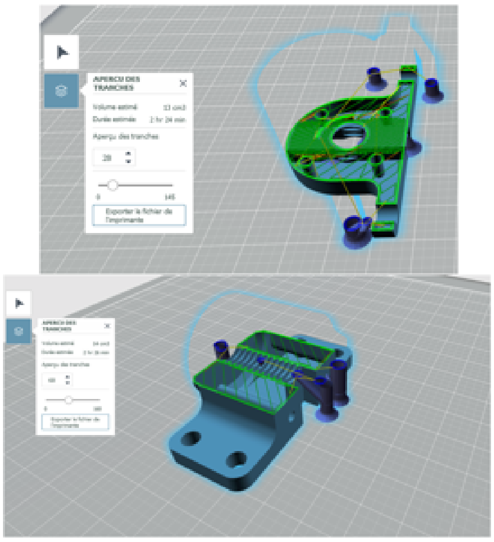

Fig. 9 Profile of threaded 3d printed Print Studio top vertical generation, bottom horizontal generation

Considerations on the implementation of the 3d printing machine control program

For generating the printer ordering program, there are differences in the duration of generation and the amount of material consumed. For the first variant in (table 2) which is the centralized data for part considering the nut generated conventional.

Table 2

DATA FOR 3D PRINTED PART IN NEW CONVENTIONAL SITUATION

No	Pozition	Time	Layer	Line	Filament	Slicer	Slicer
		min			mm		
1	Vertical	52	155	109565	3103	Cura - Repetier	
2	Horizontal	62	185	73810	3635		
3	Vertical	80	154	105111	5095	Print Studio	Optimim
4	Horizontal	106	185	101857	6552		

For the second all centralized version (table 3), the specific data is presented. It should be shown that between these estimated and actual data there are differences.

Table3

DATA FOR 3D PRINTED PART IN NEW PROPOSED SITUATION

No	Pozition	Time	Layer	Line	Filament	Slicer	Slicer
		min			mm		
1	Vertical	104	145	190648	6193	Cura -	
2	Horizontal	105	160	94936	6363	Repetier	
3	Vertical	144	145	167805	9463	Print	Optimim
4	Horizontal	146	160	93863	10191	Studio	

In (fig. 8 and 9) are presented the selected generation parameters for layers in the original variant *Line width* 0.4 *Quality* 0.2 mm, and *Print speed* 45 mm/s, *Outer perimeter speed* 30 mm/s, *Infill speed* 70 mm/s, *Thickness top/ bottom* 5, *Shell top/bottom* 6.

From the study of values in (table 2 and 3) the value for columns solution has more filament consumption than the linear one by almost 40%, the generation time is higher by 45%, and the number of lines generated shows a non-uniform variation between the two situations. Also, if it is analysing the value for vertical positioning compared to the one with horizontal positioning the time value is for any of the smaller variants by 10% for the conventional solution and for the new duration is roughly equal.

Thread part generated with 3D PRINTING

A Fabrikator Mini [2] printer was used for 3D printing parts. In (fig. 10) it is presented first of this part. From the constructive point of view the made part shows a series of defects in the cylindrical exterior form due to the generation mode. The measurement of the outer and inner diameters results in (table 4.). In order to better observe the positioning of the measured elements they were explained in (fig. 11). For a better view of the printed part it was posed both from the lateral side on left and from the small cylinder image on the right (fig. 10.).

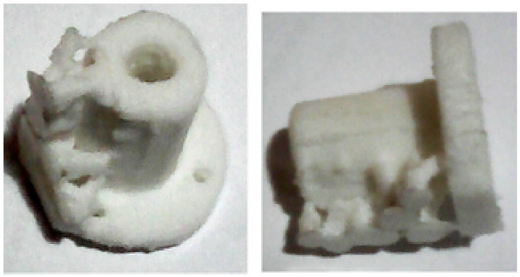

Fig. 10.Conventional part with linear supports left vertical position, right lateral position

Table 4

DIMENSIONAL VALUE FOR PART WITH CYLINDRICAL SUPPORTS

Dimension	UM	Value
Lenght	mm	31,00
Small diam 1	mm	18,10
Small diam 2	mm	18,20
Large diam 1	mm	36,00
Large diam 2	mm	34,00
Iner diam tap 1	mm	6,00
Iner diam tap 2	mm	6,50

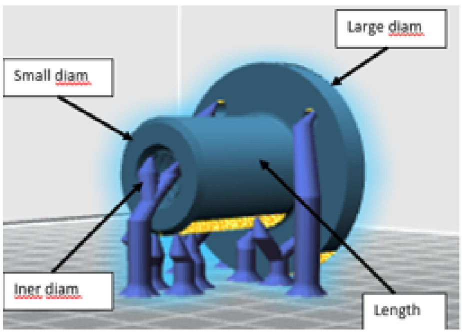

Fig. 11. Dimnesion for convetional part with cylindrical supports

In (fig. 12) it is presented the second of this part. From the constructive point of view the made part shows a series of defects in the cylindrical exterior form due to the generation mode. The measurement of the outer and inner diameters results in (table 5). For a better view of the printed part it was posed both from the lateral side on left and from the small cylinder image on the right (fig. 12.). In order to better observe the positioning of the measured elements they were explained in (fig. 13).

Fig. 12.Conventional part with linear supports left vertical position, right lateral position

Table 5
DIMENSIONAL VALUE FOR PART WITH LINEAR SUPPORTS

Dimension	UM	Value
Lenght	mm	31,00
Small diam 1	mm	18,70
Small diam 2	mm	17,70
Large diam 1	mm	35,10
Large diam 2	mm	36,10
Iner diam tap 1	mm	6,10
Iner diam tap 2	mm	6,00

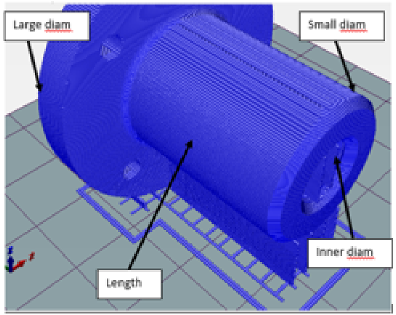

Fig. 13. Dimension for conventional par with linear supports

In figure 14 it is presented the part vertical generated in the two-position horizontal and vertical and the dimension for this generation. In order to better observe the positioning of the measured elements they were explained in fig. 15. The measurement of the outer and inner diameters results in table 6.

Table 6
DIMENSIONAL VALUE FOR VERTICAL PRINTED PART

Dimension	UM	Value
Lenght	mm	31,20
Small diam 1	mm	18,40
Small diam 2	mm	18,30
Large diam 1	mm	35,90
Large diam 2	mm	36,30
Iner diam tap 1	mm	6,40
Iner diam tap 2	mm	6,45

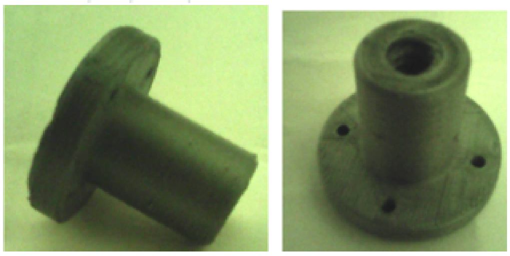

Fig. 14. Vertical print part left horizontal, right vertical

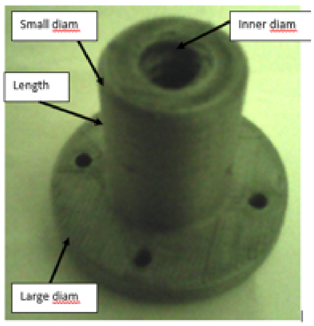

Fig. 15. Dimensional for verical print part

In (fig. 16) it is presented the part composed in the two-position horizontal and vertical. From the constructive point of view the made part shows that are not defects in the cylindrical exterior form due to the generation mode.

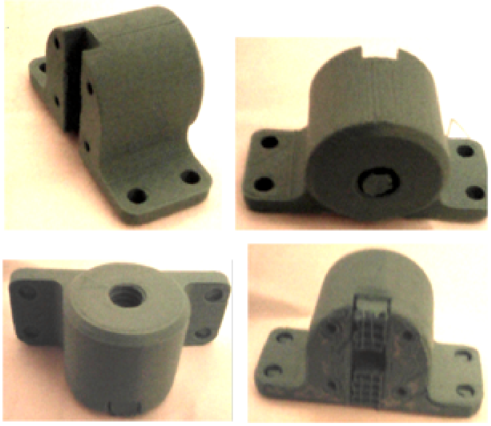

Fig. 16. Part composed is all position with linear supports top left horizontal axis, bottom vertical printing axes left front, right lateral

The measurement of the outer and inner dimensional value and diameters results in (table 7). For a better view of the printed part it was posed both from the lateral side on left and from the front part image on the right for first horizontal generation and vertical generation in the second row (fig. 16).

In order to better observe the positioning of the measured elements they were explained in (fig. 17).

Table 7
DIMENSIONAL VALUE FOR PART COMPOSED IN ALL POSITION

Dimension	UM	Value o	Value v
Lenght	mm	29,70	28,45
Large diam 1	mm	31,40	31,60
Large diam 2	mm	31,40	32,10
Iner diam tap 1	mm	7,80	7,55
Iner diam tap 2	mm	7,80	7,70

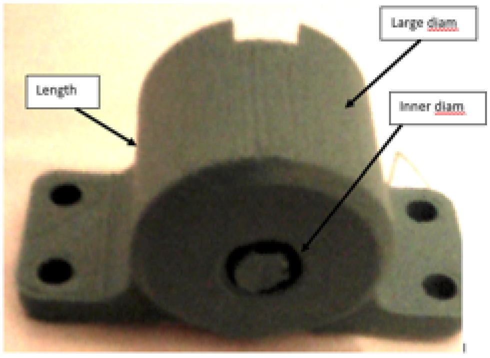

Fig. 17. Dimensional value for part composed in all position

For each of these components was then determined their weight after generation and after removal of the supporting elements. Subsequently, the weight was determined after the boring calibration operation of the inner hole and the calibration with thread tap specific to the screw hole. In (fig. 18.) are the tools with which are made the processing. At top the boring calibration tool and at bottom the tap tool.

This process is necessary because the inner surface as can be seen from the generation phase is not perfectly circular and will produce friction punctual contact areas. After processing the marks were also weighed determining

Fig. 18. Tools for inner calibration of the screw hole

Table 8
DIMENSIONAL WEIGHT FOR PART STEP BY STEP FOR PARTS

Type	Weigth in grams				Loss %
	with sup	aut sup	tap	thread	
Norm_Cil	12,50	12,30	11,90	11,60	7,76%
Norm_lin	11,90	11,80	11,70	11,45	3,93%
Norm_vert	11,50	11,50	11,40	11,20	2,68%
Modif_ori	19,70	19,50	19,30	19,10	3,14%
Modif_vert	19,30	19,10	18,90	18,70	3,21%

Fig. 19. Pharmacy balance for weight the part

their final weight. The weight values are centralised in the table in (table 8).

In (fig. 19) is presented the stand to determine the weight of the samples. It's a pharmacy balance with the accuracy of 0.1 g.

The data analysis in relation to the (table 8) of parts 3D printed can be concluded that the lowest loss of material and implicitly the lowest corrections are obtained for 3D printing in the vertical position for the conventional element and in relation to the second item losses are relatively close, but the material consumption is lower for the vertical position than the horizontal one. Consequently, in addition to the form of the generation of the spire it is recommended to consider also the consumption of material for the performance of the part 3d printed.

Conclusions

The present study is intended to be a beginning of research on the generation of screw hole for parts generated with 3d printing method with FDM technique. One of the directions is the determination of the maximum transmitted force, but also another direction is the determination of the friction coefficient developed on the contact surface. Finally, determinations will be made on the accuracy of the positioning of repetitive running and on variable force requests respectively.

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