# Influence of Constructive and Technological Parameters at Generated Spiral Parts with DLP 3D Printing Process

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*This work are made for determine the possibility of generating the specific parts of a threaded assembly. If aspects of CAD generating specific elements was analysed over time in several works, the technological aspects of making components by printing processes 3D through optical polymerization process is less studied. Generating the threaded appeared as a necessity for the reconditioning technology or made components of the processing machines. To determine the technological aspects of 3D printing are arranged to achieve specific factors of the technological process, but also from the specific elements of a trapezoidal thread or spiral for translate granular material in supply process are determined experimentally. In the first part analyses the constructive generation process of a spiral element. In the second part are identified the specific aspects that can generation influence on the process of realization by 3D DLP printing of the two studied elements. The third part is affected to printing and determining the dimensions of the analysed components. We will determine the specific value that can influence the process of making them in rapport with printing process. The last part is affected by the conclusions. It can be noticed that both the orientation and the precision of generating solid models have a great influence on the made parts.*

*Keywords: 3D printing; fabrication parts; dimension threaded, resin material, DLP printing*

## Consdructive and dimensional aspects at generation of the spiral part

CAD realization of spirals can be made using more than one method [1-7]. The first of these is a graphical method that adds a picture surface generated and that is most used. The second method is the cutting generation in a cylindrical surface of the spiral using as directory to generating. The cutting sections called generators may be of different shapes. For the case of this paper, we will use triangle [8] and arc type generating element respectively. The advantage of the generating of the spiral element in a structure may be reducing the number of items that needed for making the assembly [6, 7, 9]. If the first two variants are, the accomplishment of cylindrical spiral type elements, the third variant are generated the planar spiral (Figure 1.) or conical spiral elements (Figure 2.).

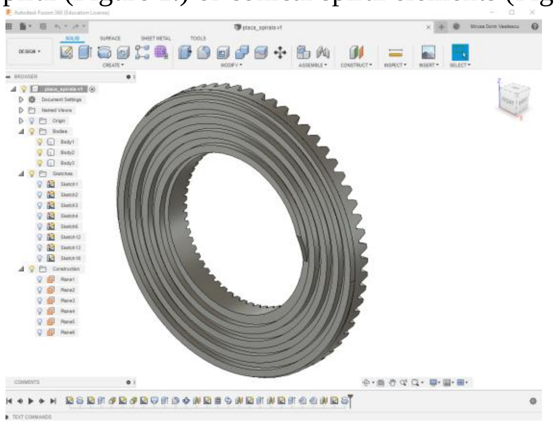

Fig. 1. Geometry 3D printed plan spiral

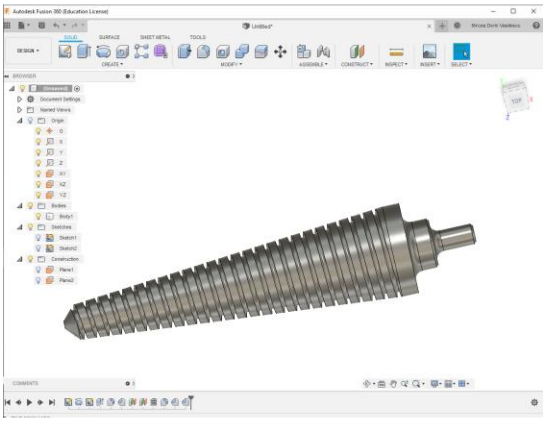

Fig. 2. Geometry 3D printed conical spiral

Spiral plan element was generated for the realization of a lathe chuck 3D printed with functional but also didactic role. Spiral element rotated after Z-axis with the help of a conical gear disposed on the opposite side of the spiral surface. That is specific to a universal lathe with a diameter of 50 mm. To generate the specific interface Design we used module from [5, 10, 11]. Spiral surface is subject to a solicitation of sliding friction. Conical gear surface is subject to a solicitation for contact pressure.

The rotation of the conical spiral component is made after the horizontal axis X. This is used for the alimentation with granular material in an installation for abrasive water jet cutting. From the point of view of the function of component it can be seen that in the channel will be moved a granular material. The abrasive wear solicitation of channel are very important effects.

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An important element in the field of linear motion transmission systems are the grooved bush elements (Figure 3.). The inner spiral element is linear willing after the geometric element generator.

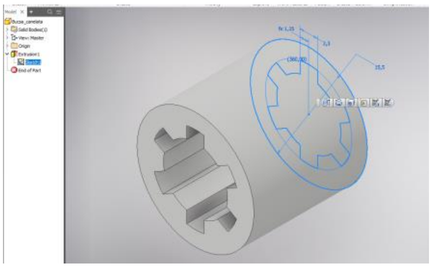

Fig. 3. Grooved bush linear CAD generated

From the point of view of the generation programme, for parts generated must consider both functional role and the geometric.

An important element for linear motion transmission systems are the threaded element (Figure 4.). The inner spiral element generated it in analyse to see how changes made can affect the generation for a complete and correct technological generation. In order to analyse the CAM generation it is important the functional role. The specific output technology has been developed to solve the last problem analyse.

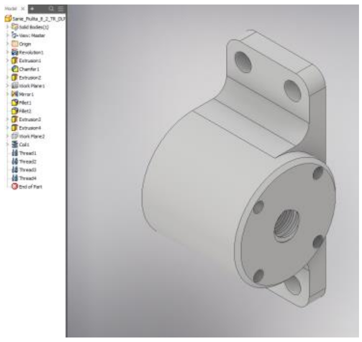

Fig. 4. Threaded to be made CAD generated

**Solid part generation aspects of 3d printing DLP process of spiral parts**

In order to made of the landmark are used an Anycubic Photon 3D printer [12] (Figure 5.). This can generated a polymerization point of 47 microns.

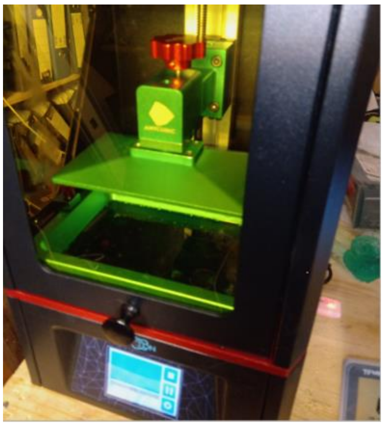

Fig. 5. 3D printer Anycubic Photon

From the point of view of generating the solid element, the precision of achieving the triangular structure for the realization of the solid model is important. Since the types of spiral elements as geometry, but also as their position are very different, the analysis made for each element in part.

This requires great precision to generation of the solid conical spiral (Figure 6.). It can see that due to the high accuracy of the solid landmark generation we have a number of 157.876 triangles number.

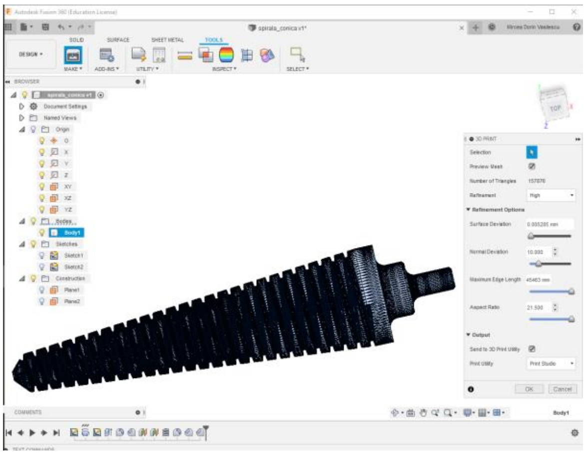

Fig. 6. Mesh part for conical spiral

For plan spiral because it requires great precision to generation of the solid plan spiral (Figure 7.). It can see that due to the high accuracy of the solid part generation we have a number of 158.038 triangles number.

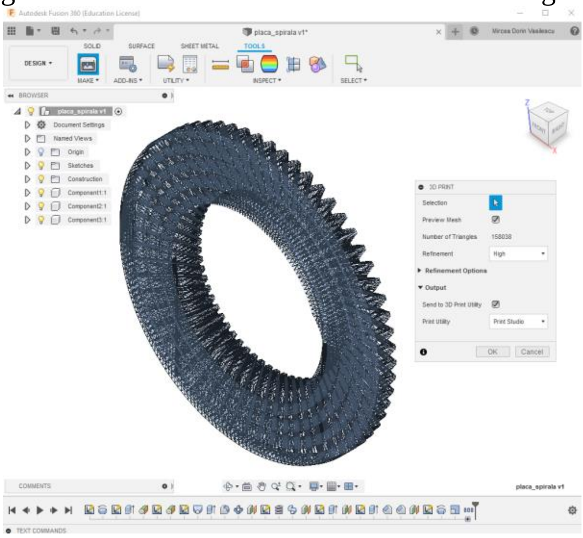

Fig. 7. Mesh part for plan spiral

For grooved bush element because it requires great precision to generation of the solid plan spiral (Figure 8.). It can see that due to the high accuracy of the solid part generation we have a number of 2.464 triangles number.

For threaded element because it requires great precision to generation of the solid trapezoidal spiral (Figure 9.).

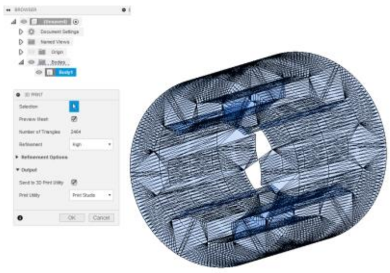

Fig. 8. Mesh part for grooved bush element

Fig. 9. Mesh part for threaded element

It can see that due to the high accuracy of the solid part generation we have a number of 18.538 triangles number.

## Pre printing aspects of 3d printing DLP process of spiral parts

An important consideration in making 3D DLP printing is the orientation of the part to generate it. Some generation file for printing programs propose the vertical position by default. The principal consideration is to minimize the footprint at the level of the flat generation surface of the part generated. One of these is Print Studio [13] for an Ember printer, which also provides the positioning of support elements to achieve the printing process. For the four parts envisaged to printing, which have spiral elements in composition, the positioning and generation of supporting elements. It is possible to see in (Figure 10.) automatic positioning for plan spiral the type of supporting.


Fig. 10. Part for plan spiral printing position

The automatic positioning and generation of supporting elements for conical spiral it is possible to see in (Figure 11.).

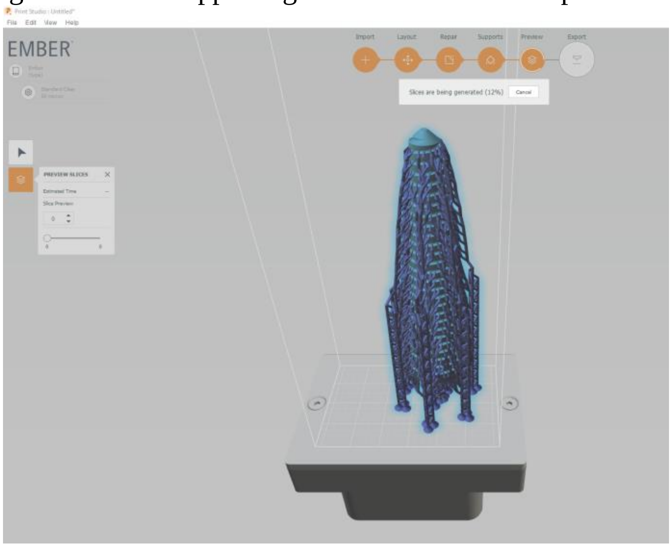


Fig. 11. Part for conical spiral printing position

The automatic positioning and generation of supporting elements for linear channel vertical position in a grooved bush it is possible to see in (Figure 12.).

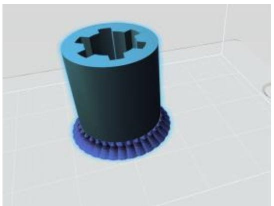

Fig. 12. Part for grooved bush element printing position

From the analysis of the last presented elements that have rectangular or profiled channels it is possible to observe that the generation and positioning performed for the CAM program for generation elements only in a vertical position. For the last analysed case, a change of the strategy of positioning supports it is possible to observe. The generation of both internal and external supporting elements it is possible to observe for the last element CAD generated. The automatic positioning and generation of supporting elements for grooved bush element to see in (Figure 13.).

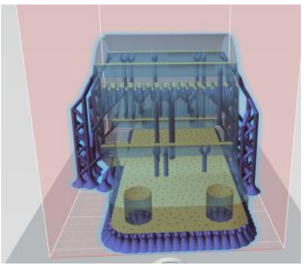

Fig. 13. Part for grooved bush element printing position

Since the orientation for the generation of the element has effects and on its printing costs, it will analyse the influences of the technological elements on these costs of processing the envisaged to printing the part.

It is possible to see from those presented that automatic orientation may not always be the optimal solution for printing the desired element. The conclusion is that the orientation of the element in the case for DLP printing process performed by the designer ability to determinate the functional conditions of the element and the experience acquired from previous print components.

An important aspect of DLP printing is also the areas that need to support in the process of printing the component. An important aspect of DLP printing is also the areas that need to support in the process of generated the part. In order to mentioned situations some programs mark with red areas where such problems (Figure 14.).

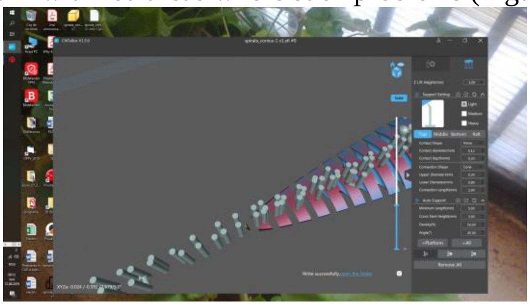

Fig. 14. Position of support for DLP printing red colour

In (Figure 15.) it is possible to see the structure of the supports prepared on the bottom of the analysed spiral element.

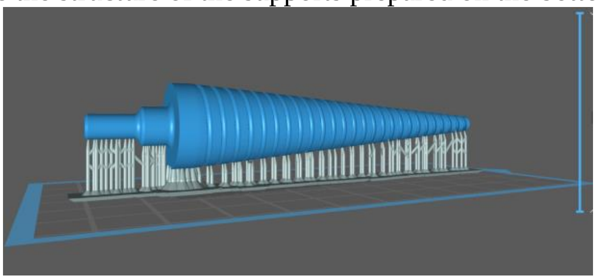

Fig. 15. Part for grooved bush element printing position

In the areas with intense red it is recommended to dispose of elements of support with dimensions of larger sections (diameter 0.6 to 0.8 mm), and in those of more open red colour support elements with smaller section (diameter 0.4 to 0.5 mm).

The importance of the supporting elements, but also how they is in position, it is possible to see from those presented. At the same time, the orientation for printing is important and it is possible to analyse in the next chapter by analysing the structure of printed part.

**Study of the dimension of part generated by 3D printing DLP process**

For analyse the effective influences of the technological parameters produce on the generated elements, two distinct experiments it is developed. The first was the one with linear channels, and the second one with spiral elements arranged at the inner side. For each of these were determined the values for the mass of the element with the support structure and respectively after its removal and compared in view of the density of the liquid environment.

The first of the elements is the one that has vertical channels on the inside. The elements study to 3D printing have been positioned a different angle to the vertical direction to observe the influence of vertical deviation to the principal dimensional elements (Figure 16.).

Fig. 16. Vertical inner channel element printing position

To view the quality of the channel it is possible to observe with the optical microscope. The quality of the upper edge it is possible to observe, but also the rounding of the contact areas between surfaces (Figure 17.).

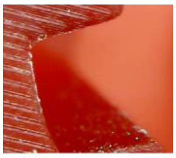

Fig. 17. Quality of the channel for vertical inner element printed

In table 1 it is possible to see the variation of the mass for the linear channel element.

**Table 1**
DATA FOR 3D PRINTED LINEAR CHANNEL PART MASS

| Angle | Mass in gram | | |
|---|---|---|---|
| in grd | Total | Part | Suports |
| 10 | 2,9 | 2,2 | 0,7 |
| 20 | 2,9 | 2,2 | 0,7 |
| 30 | 2,8 | 2,2 | 0,6 |

In  table 2 it is possible to see the variation of the principal dimension for the linear channel element.

**Table 2**
DIMENSIONAL DATA FOR 3D PRINTED LINEAR CHANNEL MASS

| Angle | Heigth in mm | | Angle | Diam int in mm | |
|---|---|---|---|---|---|
| in grd | Vert | Horiz | in grd | Vert | Horiz |
| **10** | 14,89 | 15,14 | **10** | 11,48 | 11,45 |
| **20** | 15,03 | 15,18 | **20** | 11,50 | 11,56 |
| **30** | 15,09 | 15,22 | **30** | 11,54 | 11,60 |

From tabular data, it is possible to see that the angle of inclination in printing process has influence both at the height and at the level of the inner diameter. Due to the small size, an experiment it possible to be made for large dimensions. The flanged cylinder elements arranged in the three characteristic printing positions (Figure 18.).

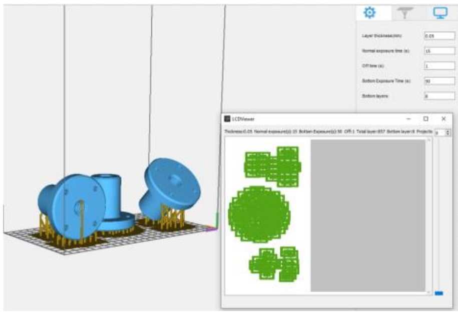

Fig. 18. Part threaded element automatic printing position

The upright position (Figure 19.) has a mass of 20 grams and a perfectly circular form. The layout with the cylindrical part with small diameter on the last portion of the print is better than the other way around.


Fig. 19. Vertical printed position for threaded component

Mass after removal of supports was 17.3 grams. The diameter of the large cylinder horizontally is 38.95 mm and vertically 38.92 mm. Small diameter horizontal cylinder 20.05 mm and vertical 20.08 mm.

Mass with supports for horizontal solution is 18.7 grams (Figure 20.).


Fig. 20. Horizontal printed position for threaded component

Mass after removal of supports was 16.3 grams. The diameter of the large cylinder horizontally is 38.93 mm and vertically 37.79-mm. Small diameter horizontal cylinder 20.29 mm and vertical 19.35 mm.

Mass with supports for horizontal solution is 17.8 grams (Figure 21.).


Fig. 21. 45 degree printed position for threaded component

Mass after removal of supports was 15.5 grams. The diameter of the large cylinder horizontally is 38.12 mm and vertically 37.90-mm. Small diameter horizontal cylinder 20.39 mm and vertical 19.85 mm.

Due to the observed ovality but also the resulting defects for printing the parts in the other two positions, the disposition of the supports restored for the position. The arrangement it made so that they arranged on a larger area (Figure 22).

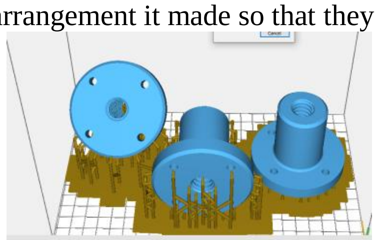

Fig. 22. Part threaded printing manual position modify

The solution of the printed parts it is possible to see in (Figure 23.) and observed the mass of the ensemble that is 58.40 grams.


Fig. 23. Part modify threaded elements element printed

From the figure, it is possible to see that the parts have the full form, complete structure, and correct reason for use this technology for working. We can therefore conclude that the technological variant envisaged recommended to continue to apply. From a dimensional point of view and the surface characteristics, the analysis presented in this way.

Mass with supports for horizontal solution is 18.40 grams. Mass after removal of supports was 15.70 grams. From the analysis of structure, it is possible to see that is not a good solution (Figure 24.). The diameter of the large cylinder horizontally is 38.64 mm and vertically 37.82 mm. Small diameter horizontal cylinder 19.90 mm and vertical 19.64 mm.

Fig. 24. Horizontal printed position for threaded component

Mass with supports for horizontal solution is 18.80 grams. Mass after removal of supports was 15.90 grams. Mass after corrected the thread with tool for thread is 15.90 grams. From the analysis of structure, it is possible to see that is not a good solution (Figure 25.).  The diameter of the large cylinder horizontally is 37.84 mm and vertically 37.82 mm. Small diameter horizontal cylinder 19.91 mm and vertical 19.92 mm. The figure it is possible to see on the right side of the 3D printed element via FDM type of printing. On the left side, the item to which no removal of material from the DLP-printed threaded part was no longer required. It is also possible to observe the superior quality of the exterior surface resulting from the printing.

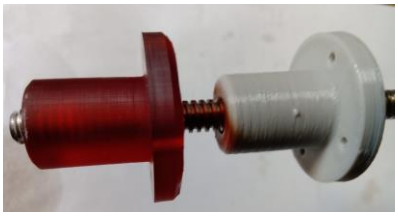

Fig. 25. Horizontal printed position for threaded component

Mass with supports for 45-degree solution is 21.10 grams. Mass after removal of supports was 15.80 grams. From the analysis of structure, it is possible to see that is not a good solution (Figure 26.).  The diameter of the large cylinder horizontally is 39.33 mm and vertically 37.20 mm. Small diameter horizontal cylinder 19.88 mm and vertical 19.34 mm. From the figure, you it is possible to see a slight deviation of the median plane of the large diameter cylindrical element.

Fig. 26. 45 degree printed position for threaded component

The thread part modify have been printed in the optimum position for the geometric element of the trapezoid type (Figure 27.). The mass of the part with the supports is 36.9 grams and without the supports is 33.40 grams.

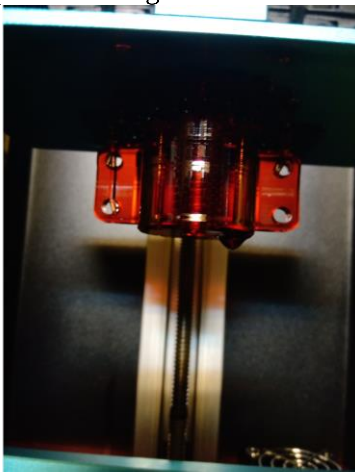

Fig. 27. Part thread part with fixing element printed

The generated/printed component was optical inspected and then checked to the way it assembles with threaded rod. Mounting was easy and good functionality (Figure 28.).

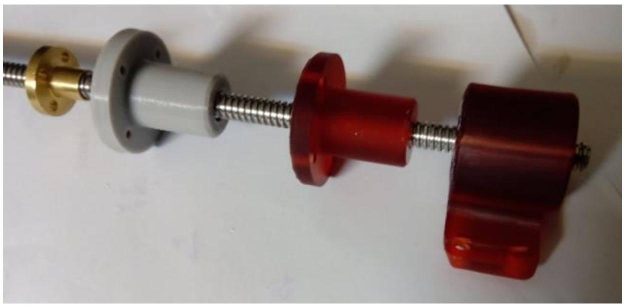

Fig. 28. Printed components for inner threaded element

Making the part with the spiral plane system is a special element to which both sides have a functional role. The toothed part have a role of transmitting rotation and the spiral part of generated the translation movement. It has thus been chosen to ensure the circularity of the element, as observed from the first two studies, it has been chosen that the supporting elements are on the spiral side (Figure 29.).


Fig. 29. 3D printed plan spiral with supports

At the same time, it is possible to observe the mass of the assembly 10.9 grams and of the part 6.9 grams in (Figure 30.) The mass of the supporting elements are 4 grams.

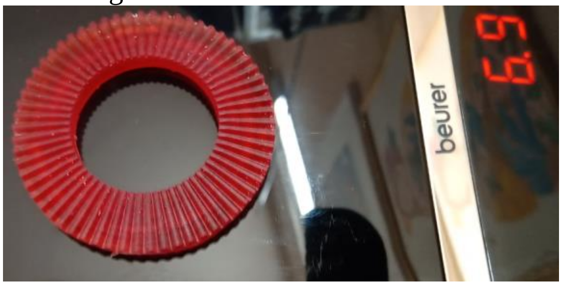


Fig. 30. 3D printed plan spiral

The horizontal print position on the supporting face appears flatness and precision printing problems. Due to this, the printing with different orientations and angles.

In order to be able to highlight which positioning solutions are better for such a component, prints with medium-sized supports in two different variants of the horizontal it made. The first is with the downward part tilted to 15 degrees (Figure 31.).

From the analysis of surface quality on the printed face, it is possible to note that we have an ovality on the cylindrical lateral surface. The peripheral diameter of the printed element has a maximum value of 52.02 mm and a minimum of 51.43 mm. This ovality will cause an uneven arrangement of the gap between the teeth. Bigger is the void on the side on which the arrow ordered on the photo. It therefore follows that the high tilt angle will result in greater ovality, and a small tilt angle an almost circular shape. From the point of view of the mass of the mark, there is a match between the values determined whichever is the orientation position.

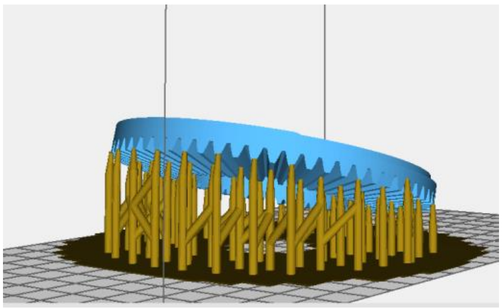

Fig. 31. 3D printed plan spiral with gear bottom

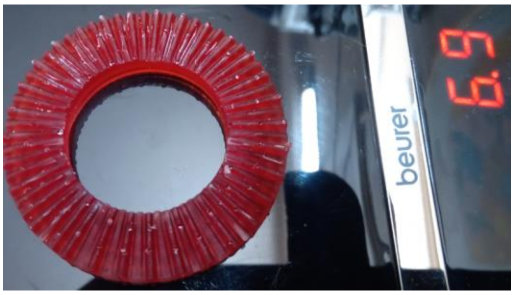


Fig. 32. 3D printed plan spiral with gear bottom

The second variant is with the spiral side under the same conditions mentioned below (Figure 33.).

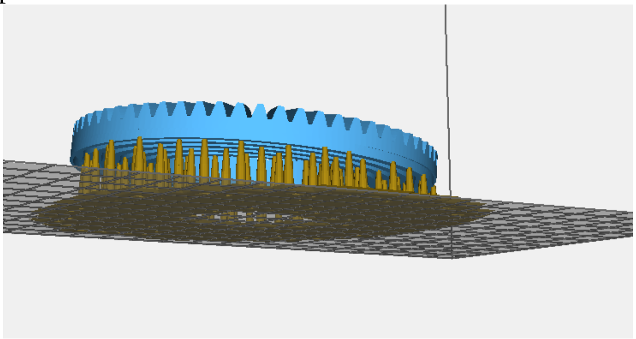

Fig. 33. D printed plan spiral with spiral bottom

In (Figure 34.) it is possible to see that on the printed side spiral shape is good. The spiral deformation is very small in the degree of precision admitted by the channel. An important observation is the one that takes into account the treatment of ovality in 3D printing. It is possible to done in the part of the solid generation.

Making the part with the conical spiral system is a special element to conduct materials in a system for water jet machine. It has thus been chosen to ensure the circularity of the element, as observed from the first two studies, it has been chosen that the supporting elements are on the bottom side (Figure 35.).

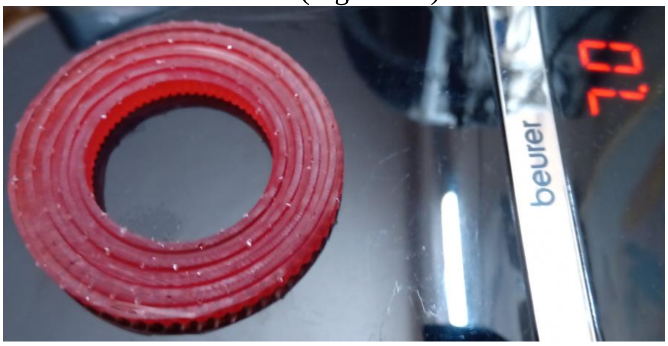


Fig. 34. 3D printed plan spiral with spiral bottom

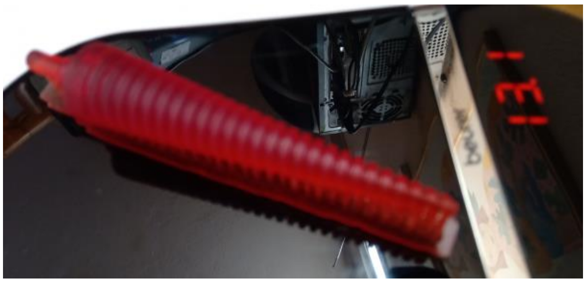

Fig. 35. 3D printed conical spiral with supports

At the same time, it is possible to observe the mass of the assembly 13.1 grams and of the part 10.6 grams in (Figure 36.) The mass of the supporting elements are 2.5 grams. In order for the surface to be, less affected, average double size supports used as a number. The dimension of this type of supports have a diameter of 1.2 mm and a diameter measured by 1.51 mm (Figure 37.),

Fig. 36. 3D printed conical spiral

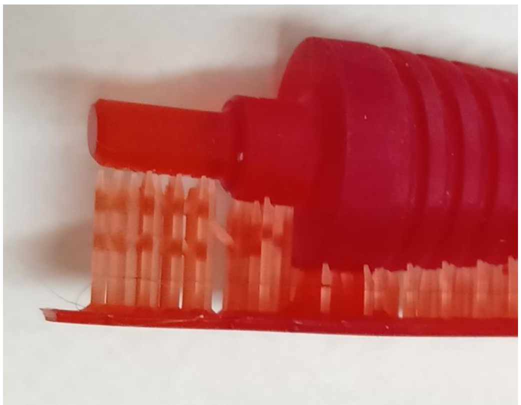

Fig. 37. Supports for 3D printed conical spiral

It is possible to see from those presented that both the dimensions of the elements printed, but also their position, have a great influence on the parts with a printed spiral element. In addition, the orientation in a given position and orientation of the part has a lower or greater influence on the print of the elements.

## Conclusions

The present study intended to be a complex research on the generation of thread parts generated with 3D printing method with DLP technique. One of the technological directions is possible to determinate the optimum solution for different type of thread element. Finally, by the working it is determinate the accuracy of the positioning of surface generated for the part, which is take in consideration.

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