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.

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].

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.

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

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

Fig. 3.The program GCode to flank involute wheel

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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.

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.

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.Anycubiq 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

| Input Parameter         | Value | UM |
|-------------------------|-------|----|
| layer thicknesses       | 20    | 50 |
|                         | 40    | 50 |
|                         | 50    | 50 |
|                         | 70    | 50 |
|                         | 80    | 50 |
|                         | 90    | 50 |
|                         | 100   | 50 |
|                         | 20    | 50 |
|                         | 30    | 50 |
|                         | 40    | 50 |
|                         | 50    | 50 |
|                         | 60    | 50 |
|                         | 70    | 50 |
|                         | 80    | 50 |
|                         | 90    | 50 |
|                         | 100   | 50 |

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.

**Table 3**

**DIMENSIONAL VALUE FOR BLANK HORIZONTAL DLP 3D PRINTING**

| Type       | Design | Made  | Dev.% | UM | Obs.   |
|------------|--------|-------|-------|----|--------|
| Height Top | 10.00  | 9.08  | -3.20%| mm | Top supports |
| Height Base| 12.00  | 12.33 | 2.75% |    |         |
| Height middle | 4.00  | 4.03  | 0.75% |    |         |
| Hole inner  | 5.00   | 5.01  | 0.20% |    |         |
| Hole middle | 8.00   | 8.27  | 3.37% |    |         |
| Diam Output| 44.00  | 46.02 | 4.59% |    |         |
| Diam middle 1 | 38.00 | 39.51 | 3.77% |    |         |
| Diam middle 2 | 14.00 | 14.73 | 5.21% |    |         |

**Table 4**

**DIMENSIONAL VALUE FOR GEAR DLP 3D PRINTING**

| Type       | Design | Made  | Dev.% | UM | Obs.   |
|------------|--------|-------|-------|----|--------|
| Diam Output 1 | 45.52 | 47.74 | 4.65% | mm |        |
| Diam Output 2 | 16.75 | 17.17 | 2.66% |    |        |
| Diam middle 1 | 20.00 | 21.23 | 6.15% |    |        |
| Height Top  | 22.00  | 22.20 | 0.91% |    |        |
| Height Base | 10.00  | 11.04 | 10.40%|    |        |
| Height middle | 11.00 | 11.44 | 4.00% |    |        |
| Hole inner  | 5.00   | 5.03  | 0.60% |    |        |

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**

| Type       | Value | Mass  | With Supports | Part | Dev.% | Obs.   |
|------------|-------|-------|---------------|------|-------|--------|
| Horizontal | 8.9   | 9.97  | 13.60         | 9.10 | -8.73%|        |
| 3D degree  | 10.1  | 11.51 | 16.20         | 8.70 | -23.08%|        |
| UM ml      | gram  | gram  | gram          | gram |       |        |
| Density    | 1.12  | g/cm³ |              |      |       |        |

**Table 6**

**DIMENSIONAL VALUE FOR BLANK 30% DLP 3D PRINTING**

| Type       | Design | Made  | Dev.% | UM | Obs.   |
|------------|--------|-------|-------|----|--------|
| Height Top | 10.00  | 10.41 | 4.10% | mm | Top supports |
| Height Base| 12.00  | 12.38 | 3.17% |    |         |
| Height middle | 4.00 | 4.15 | 3.75% |    |         |
| Hole inner  | 5.00   | 5.04  | 0.80% |    |         |
| Hole middle | 8.00   | 8.11  | 1.37% |    |         |
| Diam Output| 44.00  | 45.88 | 4.27% |    |         |
| Diam middle 1 | 38.00 | 39.41 | 3.71% |    |         |
| Diam middle 2 | 14.00 | 14.86 | 6.14% |    |         |

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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