

THEORETICAL AND DIMENSIONAL CONSIDERATIONS ON THE REALIZATION OF A LASER-BEAM ENGRAVING DEVICE FROM RECYCLABLE MATERIALS OPERATED WITH SCREW TRANSMISSION

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ABSTRACT: In this work was followed the achievement of a functional model of laser engraving at which the actuation system is made by screw nut and large part of the model structure it is made with recyclable materials. At the same time besides the constructive design of the model that is presented in the paper it is made references on how to achieve the components designed with the help of 3d printing technology emphasizing the advantages in rapport of the other known technologies until its appearance. In the paper there are analysed several technological aspects of the generation through 3d printing of the components of the model so that they can obtain parts with maximum technological efficiency and maximum functionality.
KEYWORDS: 3D printing; fabrication parts; dimension parts, FDM printing;

1. INTRODUCTION

In the laboratory practice activity but also in practice with students an important stage is the study of the design and realization of the prototypes. If this is coupled with modern methods of realization through the using of modern technologies that ensure both better environmental protection [1] and reduced manufacturing costs [2, 3], then it can be said that all criteria are met to combine the useful part of the design with the efficient part of the fabrication [4].

To make a comparison between the laser engraving system actuated with synchronous straps and the screw nut, an experimental model has been designed to be ordered with the latter system. At the same time to be able to make a comparison between electronic control systems the following system will be ordered with an Arduino board that has compact structure and not made with separate modules as was done in the experimental model which was the subject of a previous work [5].

To implement the above-mentioned conditions, it was necessary to choose from the processing technologies on that to ensure both the functionality of the control system screw nut and mechanical resistance. If from the point of view of the technologies specific to the processing field the additive can be seen that there are five types which each has the specific environment that is deposited and the energy source with which the deposit process is carried out. The first process at which the source is of thermal nature and the material is plastic, the other source is either a spot of light UV, a laser beam and the material is a resin, a laser beam and granular material, the next is the thermal soldering of layers, and the last one is the welding of granular material with electron beam. A classification of the processes and a detailed analysis is made in [6] and based on this analysis was opted for the thermal melting process called FDM. From the point of view of the material that is recommended to be used for the benchmarks referred to in [7, 8, 9] a comparative analysis is made against plastics and metallic materials, which concludes that the PLA is a material recommended for such Structures from an economic point of view.

2. PRESENTATION OF THE CONSTRUCTIVE SOLUTION

From a constructive point of view the experimental stand is carried out on a cartesian coordinate solution with a trapezoidal screw system. In the vertical direction Z it is an system with metric screw with positioning movement for laser beam. Moving the motion on the plane axis is carried out with step-by-step motors (Figure 1.).

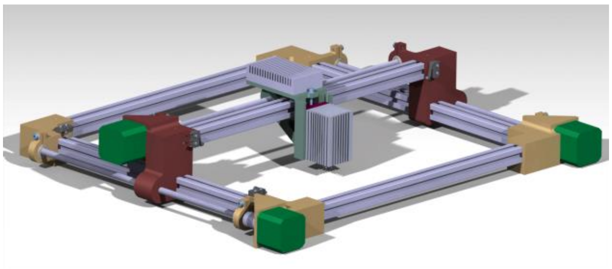

Figure 1. The constructive solution with trapezoidal screw and 3d print supports

The constructive solution was designed to adapt to several independent situations. The first of these is the command of the step-by-step motors in parallel on the longitudinal axis without only the electrical control link. The second is the positioning of linear transducers on the transverse sleigh and parallel or rotating axes at the end of the trapezoidal screws. The three is the binding with a synchronous belt transmission enter the trapezoidal screws on the parallel axes, and the last one is binding with a set of a conical gears to the side of the longitudinal displacement system. For this case we will detail the solution with the electrical link from a constructive point of view.

For longitudinal axes can be observed in (Figure 2) the chosen constructive solution. The movement guide is performed on extruded aluminium extrusion bars, and nut is generated through 3d printing directly in the nut support guide. It thus performs both a precise positioning of the guiding element and the screw to achieve the translation movement without any additional mounting components.

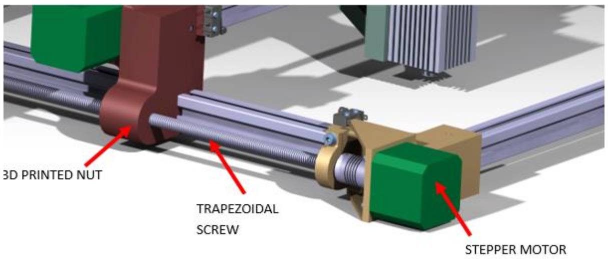

Figure 2. Trapezoidal screw actuator with stepper motor

The frame structure is obtained from 20x20 mm extruded aluminium profiles. They were preferred because they have high rigidity and at the same time it is a low mass material, which it is an advantage because the misplaced weights are not high. There were chosen bars with length of 400 mm.

In (Figure 3) it can see the installation mode of the engine, the trapezoidal screw and the coupling between these in the 3D printed structure.

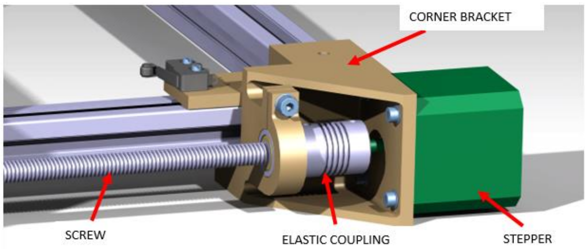

Figure 3. Installation mode for stepper and screw

The x-axis actuation is done with a fixed-step motor, the inertial mass of the assembly that turns on the X axis being smaller, but not having the effect on the inertial table of the subassembly that backstage on the Y-axis (Figure 4.).

On the y-axis the trapezoidal screws will be centred and fixed to each side with a 606ZZ bearing, the bearings fixed to the corner in a clamping slot. The gathering will be done with an M4 screw that will be in the mesh directly in the second ear being threaded on the inside (Figure 5.).

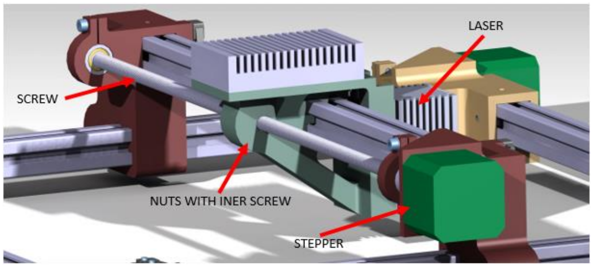

Figure 4. Stepper motor position on transversal axis

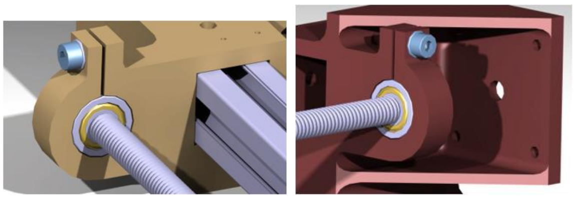

Figure 5. Screw position on left and right direction

The Y-axis actuation is done with two step-by-step motors, which are fixed to decrease the inertia mass of the subassembly that backstage on the Y-axis to ensure the parallel movement of the transverse axis (Figure 6.).

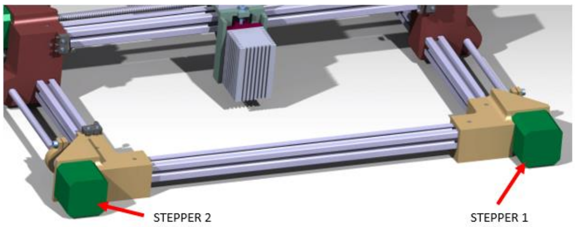

Figure 6. Stepper motor position on longitudinal axis

On the Z-axis there is no need for movement actuation, but a slight shift of the laser head is needed to focus the laser point on the workpiece surface. This displacement is carried out using a manual screw mechanism nut (Figure 7.).

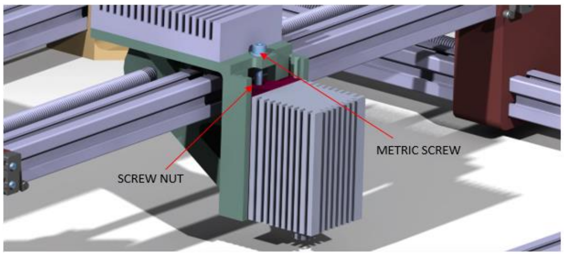

Figure 7. Vertical laser focusing

3. ELECTRONIC CONTROL SYSTEM

For the electronic command of the stepper motor, an ARDUINO UNO control system (Figure 8) will be used.

The binding and command of the stepper motors will be carried out with the A4988 driver-by-step motor-type control interfaces (Figure 9) and ensure that the current is amplified from the microcontroller level to the level required for the engine control which is Maximum 2 A.

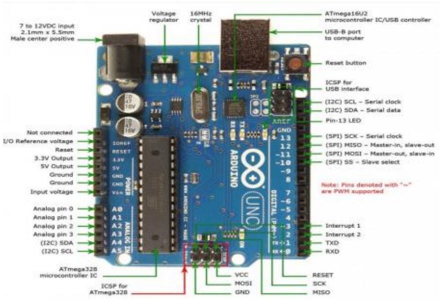

Figure 8. Arduino Uno motherboard [10]

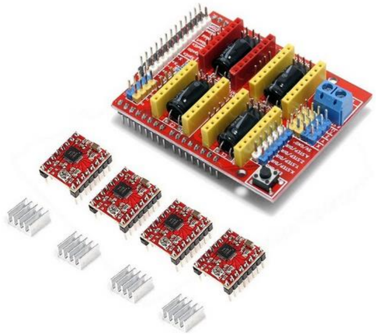

Figure 9. Step-by-Step motor interface module [11]

The control system has been designed in this open loop variant that consists of stepper motor control without checking whether the travel movement has been carried out. It should be noted that the engines after the X-axis are ordered in parallel, the same signal being transmitted simultaneously to both engines.

The command program can either be a self-conceived one based on the step-by-step motor libraries, or one that is already made of type GRBL (Figure 10.). Universal G-code sender is a Java-based program, GRBL compatible and Cross platform G-code sender. By using this program it is possible to run a GRBL controlled CNC machine. As the interface structure is organized on several distinct parts, namely the upper part of the menu, the left side of the manual commands, the right side drawing of the generation plan, and on the left side at the bottom the quotas by the axis of coordinates.

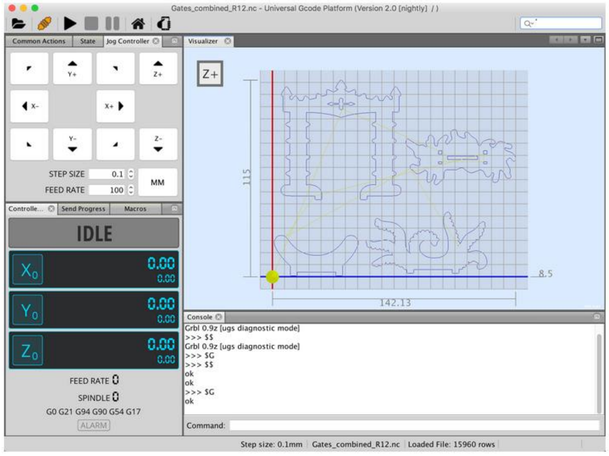

Figure 10. GRBL controlled CNC machine [12]

4. 3D GENERATED AND TECHNOLOGY OF GENERATION OF THE PARTS

From the constructive description you can see that there are three very important pieces that have a mixed functional role, namely guiding the movement, but also the transformation of the motion of rotation in motion by translation. These are the ones that come in contact with extruded guide bars and trapezoidal screws.

In this bushing, the holder has been made to insert the bar (1), holes for bar fastening screws (2), a channel through which the aluminium bar is backstage (3), a threaded hole TR 8x1.5 mm (4), an ear as a bearing holder (5) with a bearing housing (6), housing for crossing the screw to the motor (7). A notch (8), two ears (10) and clamping screw hole (9) have been carried out to tighten the bearing in the bracket (Figure 11.).

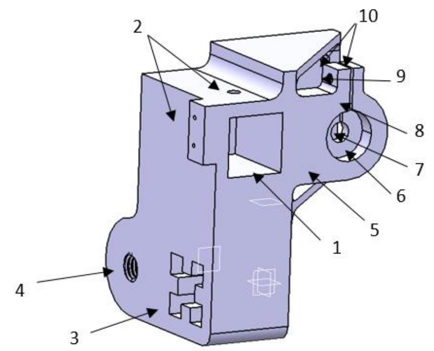

Figure 11. Support for stepper motor and guiding extruder profile

In order to achieve the positioning of this part for 3D generation we must consider the characteristics of the surface and the regime that we need to achieve for a smooth displacement with reduced friction both on the guiding part of the movement and on the transformation of the movement. For these we will consider the studies made in the laboratory [13] related to the dimensional characteristics and roughness of the surface. Last but not least we have to consider the problems that may occur when generating a circular type marker [14].

In order to generate the 3D printing command program we will use the CURA [15] program that allows us both to visualize and make the necessary corrections where required, but also to generate layers to the desired parameters. The program has two modes of operation. The first is the recommended type for those who are not experts in 3d printing and which automatically generates layers by selecting only some of the parameters. The second is the one that addresses the experts in 3D printing and which in this phase will not be used in the front work (Figure 12.).

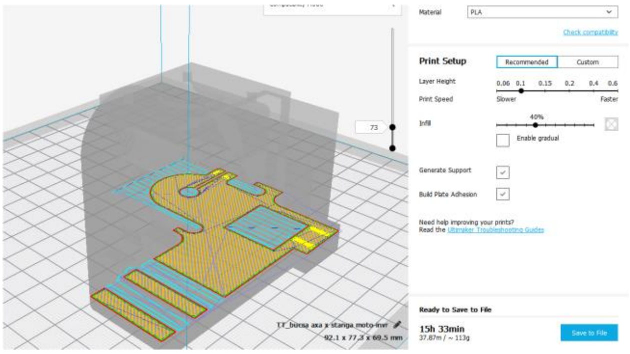

Figure 12. 3D generated 73 layer for support for stepper motor and guiding extruder profile

The printing parameters are:

- Material: PLA Standard (color: brown);
- Material density: 1.25 [g]/[cm];
- Wire length: 39776 [mm];
- Number of layers: 690;
- Total lines: 597927;
- Wire Diameter: 1.75 [mm];
- First layer thickness deposed: 0.1 [mm];
- Thickness of the layer deposed: 0.3 [mm];
- Material density of the workpiece: 40%;
- Type of line form: infill linear (form of layer interlaced at 45 degrees);
- Type of the support generation: Zig Zag;
- Weight with support generation automatic: 134 grams;
- Print Speed: 60 [mm]/[s];
- Estimated time: 15 hours 33 minutes

A modified printer of type Tevo Tarantula (Figure 13.) will be used for printing.

The second important piece is the opposite of the first (Figure 14.) to support the trapezoidal screw and which can be achieved with the same technological parameters as the first (Figure 15.) with screw generation layer obtaining the following technological results:

- Wire length: 31966 [mm];
- Number of layers: 910;
- Total lines: 597927;
- Estimated time: 12 hours 50 minutes;
- Weight with support generation automatic: 92 grams;

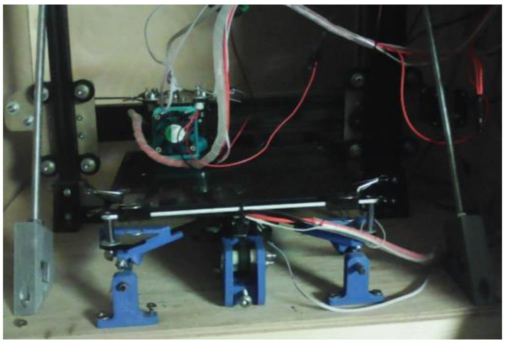

Figure 13. Tevo Tarantula printer modified

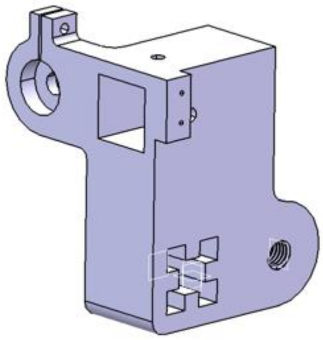

Figure 14. Support for screw and guiding extruder profile

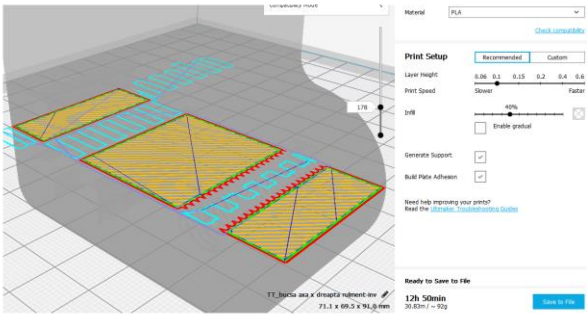

Figure 15. Support for screw and guiding extruder profile layer 178

The last important piece is the movement of the laser head (Figure 16). It can be seen that it has two functional roles, namely outside of the vertical movement, ensures the vertical translation of the laser head.

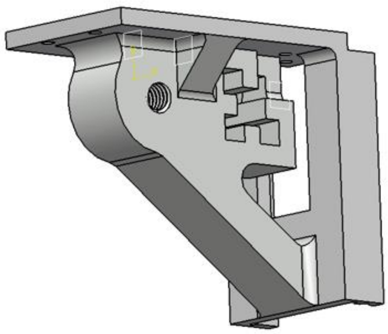

Figure 16. Central element

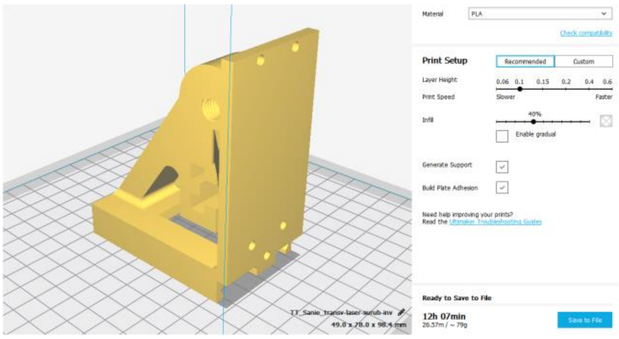

Figure 17. Layer for generated the central element

Technological parameters are (Figure 17.) with screw generation layer obtaining the following technological results:

- Wire length: 31966 [mm];
- Number of layers: 982;
- Total lines: 456310;
- Wire length: 28241 [mm];
- Estimated time: 12 hours 07 minutes;
- Weight with support generation automatic: 79 grams;

5. CONCLUSION

In conclusion it is possible to seen that such a structure can be achieved with good results for a laser engraving installation for the laboratory working made with 3d printing components, with reduced manufacturing costs approx. 860 RON the cost of the components, with an accuracy of positioning one and with precise linear movements.

6. ACKNOWLEDGEMENTS

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