

# CNC SYSTEM FOR LASER ENGRAVING AND MICROTEXTURING

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*ABSTRACT: In the research paper we chose to make a CNC laser engraving and microtexturing, used for wooden objects, polypropylene, which has a power of 10W. The points reached by the paper being the strategic marketing of the product, the project management, the establishment of specifications, the conceptual design, the manufacture and testing of the product prototype and last but not least the economic analysis.*

*KEY WORDS: CNC, engraving, microtexturing, laser.*

## 1. Introduction

Laser CNCs are modern equipment used in many industries. They are mainly found in laboratory environments, production units and various workshops. Laser engraving and cutting machines are used to engrave a variety of surfaces. The machine ensures precise cuts even at very high resolutions.

## 2. The current stage

The laser offers the fastest cutting method on the market for a wide range of materials, offers competitive and high quality products, incomparable to those made by traditional cutting techniques.

Engraving is a genre of visual arts whose techniques consist of digging, incising, perforating or obturating by various physical or chemical processes a usually flat surface, either in order to print and subsequently multiply the image, or to obtain a self-artistic object. stagnant. [2]

Laser engraving can be done on a wide range of products: wood, plastic, leather, metal, glass, etc. This procedure allows the inscription and personalization of different products with a high precision of the finest details. The market consists of: signboards, keychains, decor accessories, personalized gifts, ornaments, souvenirs, etc. [3]

## 3. Strategic product marketing

### 3.1 Identifying market opportunities

In order to identify market opportunities, the needs of future customers must first be found. Needs that will be met by the chosen product.

Thus, 4 needs were identified:

- The need to customize your own objects;
- The need to increase the quality of the processed surface;
- The need to create the product quickly;
- The need to accept the texture easily, quickly and easily

Following these needs, the following market opportunities were determined:

- Need for precise surfaces.
- For some companies or individuals it is important that the product is pleasing from an aesthetic point of view;
- Medium and large enterprises want to make the product more efficient for fast processing.

It is desired that the life of the car be as long as possible, as long as the cost is favorable, thus leading to a reduction in maintenance costs.

### 3.2 Competing products

This subchapter will illustrate CNC machines for TEXTURING AND LASER ENGRAVING present on the market. Fig. 1, 2, and 3.



Fig. 1 S6 Pro laser engraving machine, SCULPFUN, 60W, 410 x 420 mm, Silver



Fig. 2 S9 laser engraving machine, SCULPFUN, 90W, 410 x 420 mm

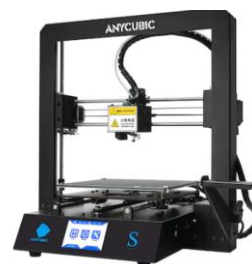


Fig. 3 Laser engraving machine, Anycubic, without SD cards, 100 mm / s, engraving area 210x210x205 mm

### 3.3 Formulation of the mission

The team aims to create an engraving and microtexturing machine that can be used in all fields at low cost.

The project reveals a device to be processed, with the help of laser power and multi-axis movements, all of which are adjusted with the help of special software.

### 3.4 Selecting potential customers - Market:

- Research institutions;
- Any person;
- Medium enterprise;
- Large enterprise that performs processing on different materials;
- Industry (metal marking with CO<sub>2</sub>);
- Architecture (3D architectural models);
- Auto industry.

### 3.5 Data from potential customers:

The elaboration of the questionnaire used for the market research in the case of the commercialization of the cnc system for texturing and laser engraving can be found in Table 1.

**Table 1. Data from potential customers**

<b>Client: Popescu Alexandru</b> <b>Address: Str. Rasaritului, no. 6, Bucharest</b> <input type="checkbox"/> <b>Ye</b> : <input type="checkbox"/> <b>Do you want to collaborate?</b>		<b>Interviewer:</b> <b>Date: 13.12.2021</b> <b>User occupation: Engineer</b>	
No. crt.	Question	Customer statement	The need interpreted
1	In what field do you work?	Production engineer	The need to increase the precision of tool guidance
2	Do you use a CNC device for laser texturing and engraving in your work?	I use such equipment	-The need to perform processing simultaneously; -The need to increase the quality of the processed surface;

<b>Client: Popescu Alexandru</b> <b>Address: Str. Rasaritului, no. 6, Bucharest</b> <input type="checkbox"/> <b>Ye</b> : <input type="checkbox"/> <b>Do you want to collaborate?</b>		<b>Interviewer:</b> <b>Date: 13.12.2021</b> <b>User occupation: Engineer</b>	
No. crt.	Question	Customer statement	The need interpreted
3	What engraving method do you use?	Deep printing method (deep engraving);	The need to increase the precision of tool guidance
4	What are the most common types of materials you use when using the CNC device for laser texturing and engraving?	stainless steel, anodized aluminum, titanium alloy;	-The need to perform processing simultaneously; -The need to increase the quality of the processed surface;
5	What are the most used operations, performed with the help of the CNC machine for texturing and laser engraving?	Answered creation	The need to perform processing simultaneously
6	Would you like to buy such equipment?	Yes, I would like to buy more efficient equipment.	-The need to perform processing simultaneously; -The need to increase the quality of the processed surface

#### 4. Establishing the objective specifications of the product

##### 4.1 List of primary requirements of relative importance

Table 2 summarizes the primary requirements.

**Table 2 Primary requirements summary**

Customer needs	Relative importance
DGL is fast	5
DGL is easily removable	4
DGL requires little physical effort.	4
DGL has a complete user manual with instructions	3
DGL is made of durable and lightweight materials.	3
DGL is easy to maintain	3
DGL is protected for overvoltage	4
DGL is portable	1
DGL has a good value for money	3
DGL takes up little space	2
DGL has a fastening and fixing device	4

##### 4.2 Identifying competing products and presenting them

Table 3 summarizes the characteristics of the competing products identified.

**Table 3 Product characteristics**

Nr.	Size / Feature	unity	Competitive products		
			AROMSTACK A5 20W	Vevor 40w Co2	FIBER LASER 30W
1	Laser power	W	20	40	30W
2	Control software	Subject	LaserGRBL	CorelDraw	EzCad

Nr.	Size / Feature	unity	Competitive products		
			AROMSTACK A5 20W	Vevor 40w Co2	FIBER LASER 30W
3	Print size	MM	410x400	300x200	200x200
4	Total weight	kg	5.6	25.65	38
5	appearance	Subjective	Pleasant	Pleasant	Pleasant
6	Maintenance and installation manual	Yes No	YES	YES	YES
7	Provides user protection	Yes No	Yes	Yes	Yes
8	Assembly / disassembly time for maintenance	min	10	25	15
9	Selling price	She	1137 Lei	2180 Lei	23 780.67 Lei

#### 4.3 Establishing the size list for the product

Table 4 shows the objective specifications, limit and ideal values.

**Tab. 4 Objective specifications (Limit values and ideal values)**

Nr. Apple.	Nr. requirement	Size / character	Relative Imp	unity	Wave. Lim.	Wave. Ideal
1	1.7	Laser power	5	W	<10	40
2	1.3	Control software	5	Subject	GRBL	GRBL
3	3.12	Print size	4	MM	300x150	340x240
4	5,8,12	Total weight	5	kg	10	8
5	5.11	appearance	3	Subjective	Pleasant	Pleasant
6	4.6	Maintenance and installation manual	4	Yes No	YES	YES
7	3.4	Provides user protection	5	Yes No	YES	YES
8	2.6	Assembly / disassembly time for maintenance	4	min	15	10
9	9	Selling price	5	She	<2400	1600

### 5. Conceptual design

#### 5.1 Clarification of the problem and definition of the general function

Based on the identified need and customer requirements, it has been established that the general function of the developed product is laser engraving.

#### 5.2 Decomposition of the general function into simpler subfunctions

The list of main functions is presented in table 5.

**Table 5 List of main functions**

General function	<i>Laser engraving</i>
<b>Nr. Service</b>	<b>The main functions of the product</b>
Ø1	Allows file transfer with information for burning
Ø2	Allows the laser head to move to the starting area
Ø3	Allows the laser head to be tilted

General function	<i>Laser engraving</i>
Ø4	The laser head applies the light beam to the engraving surface
Ø5	The laser head moves left and right in advance
Ø6	The laser head retracts into the initial "home" area

### 5.3. Establishing critical functions

Table 6 shows the critical functions of the product.

**Table 6 List of critical functions**

Nr. functions	The critical function of the product
Ø1	Allows file transfer with information for burning
Ø2	Allows the laser head to move to the starting area
Ø3	Allows the laser head to be tilted
Ø4	The laser head applies the light beam to the engraving surface

### 5.4. Generating new conceptual solutions

The database of conceptual solutions will be established by making sketches of various conceptual solutions. These are shown in Figs. 4, Fig. 5, Fig. 6 and Fig. 7.

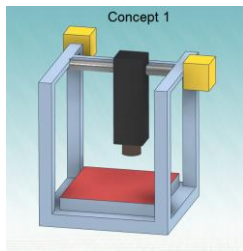


Fig. 4. Outline of the concept 1

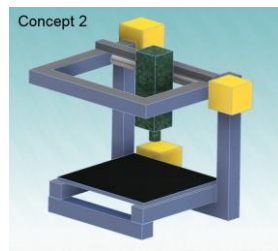


Fig. 5 Outline of the concept 2

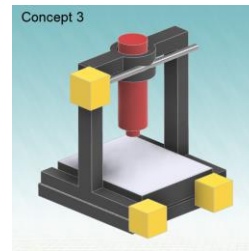


Fig. 6 Outline of the concept 3

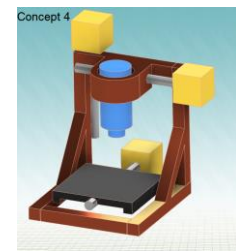


Fig.7 Concept outline 4

## 6. Detailed design

The design of the CNC device for laser engraving and microtexturing was done in the Autodesk Inventor Professional program [4]. This CNC shows 3 translational movements and a rotational movement of the laser head, see figure 8. The predominant materials in its manufacture were aluminum and steel, it having a design weight of 6.5 kg.

Description of an operating cycle:

1. Power the CNC device to a 220w power source
2. Connecting the CNC device to a G-code source (stick, computer, tablet)
3. Attaching the semi-finished product to the work table.

The blank is installed on the table of the CNC Engraving Device in a position that allows easy insertion and removal, as well as reaching the laser module at all processing points.

The part is installed in the device as follows:

- place the part on the table of the car
  - the T-head screws are inserted in the channels of the machine table
  - the processing phases are performed successively
  - after finishing the processing, proceed in the opposite direction to remove the part from the device, being able to resume a new processing cycle.
4. Running the G code
  5. After finishing the processing, proceed in the opposite direction to remove the part from the device, and a new processing cycle can be resumed.

The device is cleaned of debris and lubricated at the end of each part exchange or whenever needed.

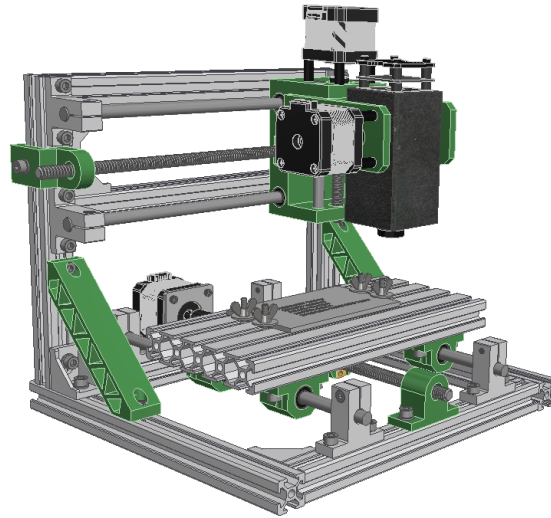


Fig. 8 The 3D model

The components were shown in Figs. 9.

In fig. 10 shows a list of materials but also the name of the elements according to fig. 8.

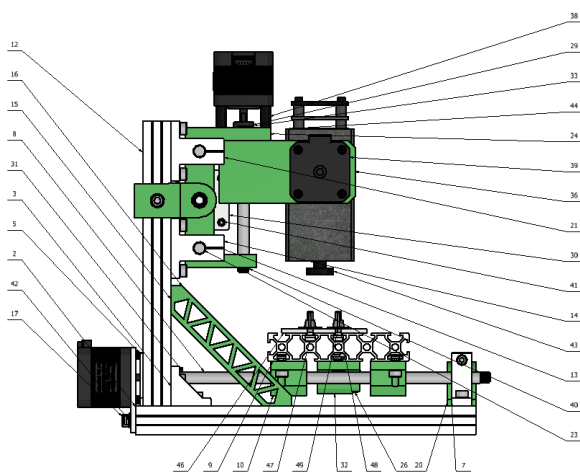


Fig. 9 Component elements

Pos	Name	Qty	MATERIAL	kg	Mass (kg)	
1	2020 Extrusion - 220 mm	4	Aluminum	0.297103	kg	
2	2020 Extrusion - 240 mm	2	Aluminum	0.223865	kg	
3	2020 Corner	10	Aluminum	0.037648	kg	
4	SK8 Linear Shaft Support, 8mm	1	Aluminum	0.011793	kg	
5	SK8 Linear Shaft Support, 8mm_1	1	Aluminum	0.011793	kg	
6	SK8 Linear Shaft Support, 8mm_2	1	Aluminum	0.011793	kg	
7	SK8 Linear Shaft Support, 8mm_3	1	Aluminum	0.011793	kg	
8	8mm x 240mm Shaft	2	Steel	0.094801	kg	
9	20100 Extrusion - 180 mm	1	Aluminum	1.127633	kg	
10	LMSBU Holder	4	Aluminum	0.09344	kg	
11	LMSBU	8	Steel	0.009525	kg	
12	2020 Extrusion - 200 mm	2	Aluminum	0.269897	kg	
13	SK8 Linear Shaft Support, 8mm_4	1	Aluminum	0.011793	kg	
14	SK8 Linear Shaft Support, 8mm_5	1	Aluminum	0.011793	kg	
15	Frame Handle-Support	2	Aluminum	0.200034	kg	
16	M5x10 v1	54	Steel	0.003175	kg	
17	M5 T-Slot Nut	51	Steel	0.000507	kg	
18	X-Axis Bearing Support v5	1	Aluminum	0.098883	kg	
19	688-2RS v1	4	Aluminum	0.01	kg	
20	Y-Axis Bearing Support v3	1	Aluminum	0.097069	kg	
21	SK8 Linear Shaft Support, 8mm_6	1	Aluminum	0.011793	kg	
22	SK8 Linear Shaft Support, 8mm_7	1	Aluminum	0.011793	kg	
23	8 mm x 255 mm Shaft	2	Steel	0.100698	kg	
24	Z-Carrier	1	Aluminum	0.912628	kg	
25	M8 x 15 mm Rivet nut	3	Steel	0.00499	kg	
26	TB Lead Screw Nut - 2mm Pitch	3	Steel	0.008165	kg	
27	12mm OD Dia, 0.8 mm wire diameter, 30 m	3	Steel	0.003375	kg	
28	TB-2 Lead Screw, Length = 255 mm	1	Steel	0.078471	kg	
29	Shaft Coupler_3 - 8 mm	3	Steel	0.022226	kg	
30	XY Stepper Mounting Bracket	2	Aluminum	0.054431	kg	
31	TB-2 Lead Screw, Length = 230 mm	1	Steel	0.07076	kg	
32	Y-Axis Move Assembly	1	Aluminum	0.106143	kg	
33	8 mm x 97 mm Shaft	2	Steel	0.038102	kg	
36	Z-Axis Spindle Holder	1	Aluminum	0.399	kg	
37	LMSBU	4	Steel	0.007257	kg	
38	M3 - 7mm x 15 mm Spacer	8	Aluminum	0.004	kg	
39	17RS1352-P4130 NEMA17 Stepper	4	Steel	0.5	kg	
40	TB-2 Lead Screw, Length = 93.5 mm	1	Steel	0.028576	kg	
41	M8 x 6 mm	16	Steel	0.009072	kg	
42	M5 Washer	24	Steel	0.004536	kg	
43	Laser modul	1	-	0.05	kg	
44	Support Modul Laser	1	Aluminum	0.523	kg	
45	Laser catches	2	Aluminum	0.04	kg	
46	CS semi-finished product	1	Aluminum	0.2	kg	
47	Screw T	4	Steel	0.04	kg	
48	CNS 4573 - M 4	4	Steel	0.02	kg	
49	Washer	4	Steel	0.02	kg	
					6.502544	kg

Fig. 10 List of materials

## 7. Testing the breaking strength of the structure

FEA analysis was performed for the upper part of the device. In this analysis, forces were applied on the columns that support the laser head, but also the weight of the fastening system. As a result of these applied forces, all safety parameters have been met (see Fig. 11 and Fig. 12).

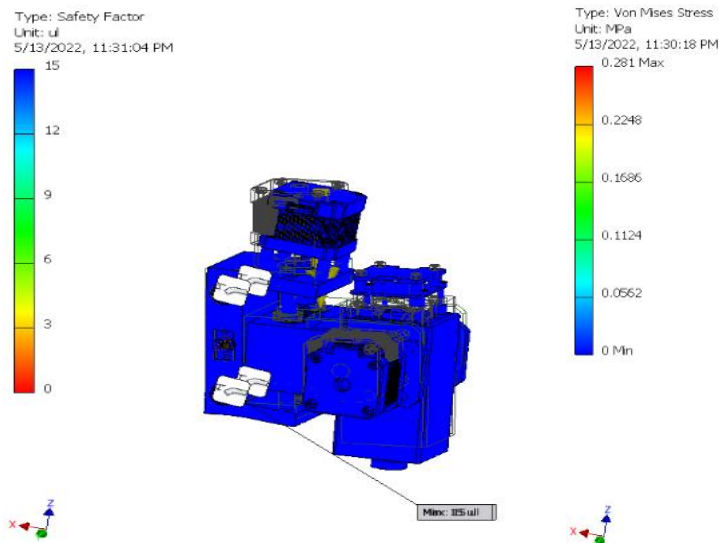


Fig. 11 Resistance factor

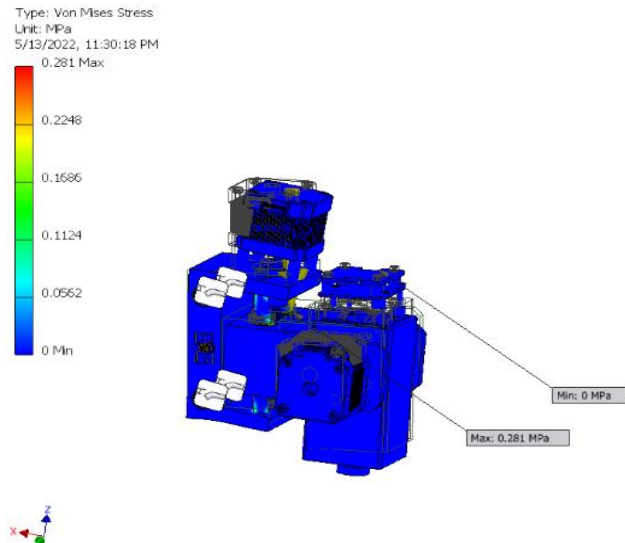


Fig. 12 The stress factor

## 8. Economic analysis

The CNC system can be traded with the following legal entities and not only, as can be seen in Figure 13:

- Raimar deals with the personalization of watches, it is located in Bucharest, Iuliu Maniu Boulevard 546-560, the distance from the Polytechnic University is 6 km; the transport cost is (15 lei - Fan Curier; 19 lei Cragus);
- Malvensky deals with jewelry personalization and is located at a distance of 5.6 km from the Polytechnic University in Bucharest, Lascăr Catargiu Boulevard 46; the transport cost is (14 lei - Fan Curier; 18 lei Cragus);

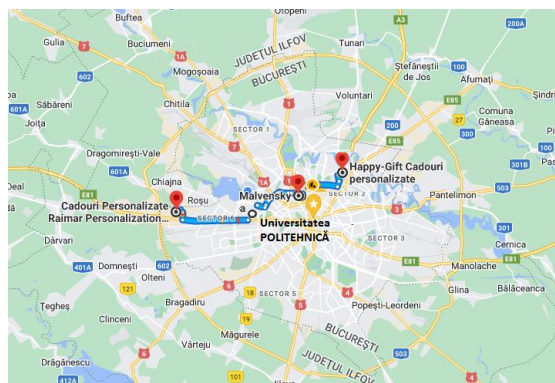


Fig. 13 Representation

All components from which the CNC System is made can be recycled and reused to make other products. Aluminum elements can be melted and reused in another form, as can plastic and steel elements.

The recycling stages of aluminum (fig.14) and steel are similar: collecting products containing aluminum and steel, sorting materials using magnets, reprocessing aluminum and steel consists of 4 steps: shredding, decorating, melting and casting, follow the transport of the cast ingots to a rolling and recycling factory and the last stage, the conversion of aluminum and steel into a wide range of products.

The data, quoted by Forbes, show that, in 2018, approximately 41.5% of plastic packaging waste was recycled in the European Union, which places Romania above the European average.



Fig. 14 Aluminum

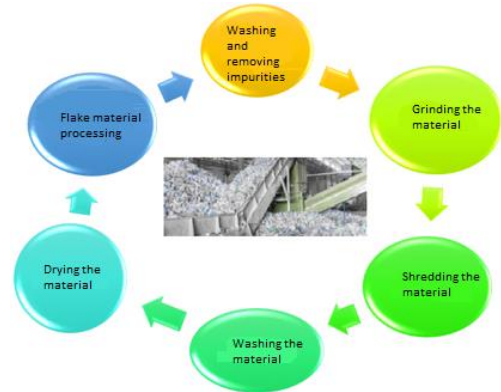


Fig.15 Stages of plastic recycling

Some components of the CNC system are represented in table 7:

Table 7. Composition table

POZ.	NAME	BUC.	COMPANY	PRICE	3D IMAGE
18	X-Axis Bearing Support	1	Fruugo	200 lei / pc	
39	17HS1352-P4130 NEMA17 Stepper	3	Fruugo	120 lei / pc	

## 9. Conclusions

Following the research, it can be seen that the device meets the economic conditions, market demands, but also FEA diagrams. We propose for future research the addition of a camera for detecting the working temperature, but also the realization of the CNC device.

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