CNC SYSTEM FOR LASER ENGRAVING AND MICROTEXTURING

NECSOIU Mihaela-Madalina, SERAFIM Georgica, PERSUNARU Gratiela-Florentina, NASTASE Gabriel

Prof. Dr. Eng. GHICULESCU Liviu Daniel

Faculty: FIIR, Specialization: INPN, Year of study: I Master, e-mail: nastase_gabriel2003@yahoo.com.

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. Stadiul actual

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. Planning the dissertation project

• Program Management Plan: establishes the processes, procedures, and documentation for planning, developing, managing, executing, and controlling project plans.
• Establishing a process for all project activities that represents the identification and documentation of specific actions that must be taken to achieve project objectives.
• Allocating resources for identified activities represents the process of estimating the type and quantity of resources, labor, equipment, or ongoing work to perform project activities.
• Estimating activity duration is the process of estimating the time required to complete each activity with the estimated allocated resources.

The planning of the project activities was done with the help of the Primavera P6 program.

Fig. 1 Allocation of activities necessary to complete the project

Financial management and risk management

For the financial evaluation of the project, the cash flow discounting method presented in the table below was used.

Table 1

N	I0	V		Ch		CF	i		VAN	25669.82	
0						-15133			RIR	58%	
1	15133	V1	27500	Ch1	15000	12500	0.09		Cfmed	8556.605	
2		V2	36000	Ch2	18000	18000			TR	1.768575	
3		V3	51000	Ch3	21000	30000			IP	1.696281	
									TRUE	IP> 1!	

Terms of delivery

The sales process is initiated by sending an Offer by the Seller-Buyer. The offer includes: the products, the quantity, the price, the terms and methods of payment, the delivery term and is accompanied by the present general conditions.

Methods and conditions of payment

The contractor will issue the invoice for the delivered product.
VAT is added to the prices indicated above according to the regulations in force on the invoicing date. Payment will be made within a maximum of 15 days from the invoice date.

The protocol of qualitative reception will accompany the invoice and is the necessary element for making the payment, together with the other supporting documents such as:
- the quality and guarantee certificate;
- declaration of conformity;
- the shipping notice of the product;
- the reception report;

4. Evaluation of concepts

Since the number of concepts is not very large, it is not necessary to sort them, so we will make a matrix of their evaluation, table 3.

For this we choose a reference concept, in our case concept 3 because this concept is an obvious solution to the design problem. It is a simple solution, which involves relatively low costs.

The evaluation scale of the concepts was established in relation to the reference concept (concept 3), the proposed evaluation scale being from 1 to 5, where 3 is the same as the reference concept and 5 is much better than the reference concept.

Evaluation criteria were established and for each the associated sub-criteria were established, taking into account the requirements of the clients and the objective specifications. In addition, I set a weight for each one, according to what is shown in table 2.

Table 2 Selection criteria and weight of criteria

Nr. Criteriu	Criteriul de selectie	Pondere [%]
1	**Simplitatea operarii**	**15**
1.1	Se introduce cablu USB de la un PC	7
1.2	Se apasa butonul on/off	5
1.3	Verificarea statusului prin indicator LED	3
2	**Usurinta folosirii**	**10**
2.1	Usurinta punerii in functiune	3
2.2	Usurinta manevrarii	3
2.3	Usurinta curatarii dupa utilizare	2
2.4	Siguranta in functionare	2
3	**Fiabilitatea**	**15**
3.1	Componente fiabile	5
3.2	Interschimbabilitatea pieselor	5
3.3	Rezistenta si durabilitatea subansamblurilor	5
4	**Design si ergonomie**	**10**
4.1	Aspect vizual placut	3
4.2	Proportionalitatea formelor	1
4.3	Dimensiuni de gabarit reduse	3
4.4	Fixare/eliberare	1
4.5	Stabilitate in functionare	2
5	**Universalitatea**	**5**
5.1	Diverse industrii	2.5
5.2	Diferite proiecte	2.5
6	**Usurinta fabricarii**	**15**
6.1	Tipul materiilor prime si materialelor	10
6.2	Prelucrabilitatea materialelor	5
7	**Cost**	**30**
7.1	Costul fabricarii	20
7.2	Costul intretinerii	7
7.3	Costul scoaterii din uz	3

Table 3 "Concept Evaluation Matrix"

Criteriul de selectie	Pondere [%]	Concepte							
		Concept 1		Concept 2		Concept 3 (Referinta)		Concept 4	
		Evaluare	Scor ponderat	Evaluare	Scor ponderat	Evaluare	Scor ponderat	Evaluare	Scor ponderat
Simplitatea operarii	15								
Se introduce cablu USB de la un PC	7	4	0.28	4	0.28	3	0.21	4	0.28
Se apasa butonul on/off	5	2	0.1	3	0.15	3	0.15	4	0.2
Verificarea statusului prin indicator LED	3	1	0.03	1	0.03	3	0.09	5	0.15
Usurinta folosirii	10								
Usurinta punerii in functiune	3	3	0.09	2	0.06	3	0.09	4	0.12
Usurinta manevrarii	3	3	0.09	2	0.06	3	0.09	5	0.15
Usurinta curatarii dupa utilizare	2	1	0.02	3	0.06	3	0.06	5	0.1
Siguranta in functionare	2	3	0.06	3	0.06	3	0.06	3	0.06
Fiabilitatea	15								
Componente fiabile	5	3	0.15	3	0.15	3	0.15	3	0.15
Interschimbabilitatea pieselor	5	2	0.1	2	0.1	3	0.15	4	0.2
Rezistenta si durabilitatea subansamblurilor	5	3	0.15	3	0.15	3	0.15	4	0.2
Design si ergonomie	10								
Aspect vizual placut	3	1	0.03	2	0.06	3	0.09	4	0.12
Proportionalitatea formelor	1	2	0.02	2	0.02	3	0.03	3	0.03
Dimensiuni de gabarit reduse	3	3	0.09	3	0.09	3	0.09	3	0.09
Fixare/eliberare	1	4	0.04	1	0.01	3	0.03	3	0.03
Stabilitate in functionare	2	3	0.06	2	0.04	3	0.06	3	0.06
Universalitatea	5								
Diverse industrii	2.5	1	0.025	2	0.05	3	0.075	3	0.075
Diferite proiecte	2.5	1	0.025	2	0.05	3	0.075	4	0.1
Usurinta fabricarii	15								
Tipul materiilor prime si materialelor	10	4	0.4	3	0.3	3	0.3	4	0.4
Prelucrabilitatea materialelor	5	3	0.15	3	0.15	3	0.15	5	0.25
Cost	30								
Costul fabricarii	20	2	0.4	2	0.4	3	0.6	4	0.8
Costul intretinerii	7	1	0.07	2	0.14	3	0.21	3	0.21
Costul scoaterii din uz	3	2	0.06	2	0.06	3	0.09	2	0.06
Scor total			2.44		2.47		3.00		3.84
Rangul		1		3		2		4	

The concept with the best result is concept number 4. It obtained a better score than the reference concept.

Product architecture

For the chosen concept, an architecture was created in which most of the elements that will constitute the final product are described.
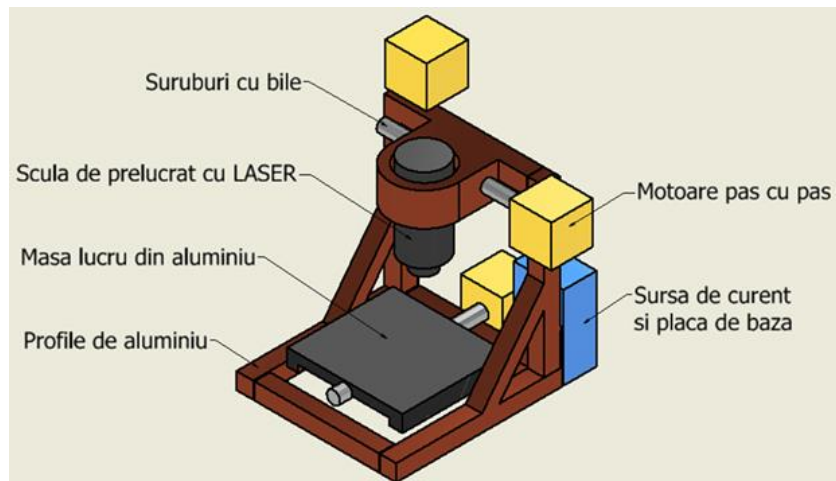
Fig. 2

5. Manufacturing – testing the product prototype

For the realization of this prototype CNC laser engraving and microtexturing I used the following materials:
- Aluminum bar
- Laser for Mini 3-Axis CNC Carving Engraving Machine PVC,PBC,wood,Chigods, 445nm 1600MW TTL PWM
- A4988 STEPPER MOTOR DRIVER
- Stepper motor, NEMA17
- Router Desktop Milling Machine CNC1610 w/ ER11 (1610 Pro)
Way of working:
- The realization of the supports for the laser and motorized module were made by hand, in a mechanical workshop.
- The electrical circuits were tested before connection with a Digital Multimeter to measure the voltage in order not to short-circuit the existing motherboard.
- To program the laser module and the stepper motor, I used 2 software: Arduino IDE and LaserGRBL.

Fig. 3 Support Laser Mode

Fig. 4 Engine support
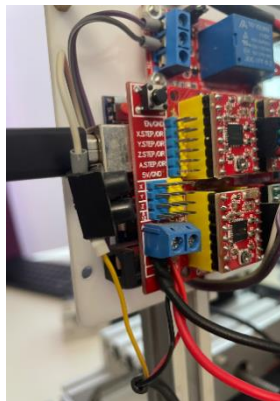
Fig. 5 Connect Laser Mode
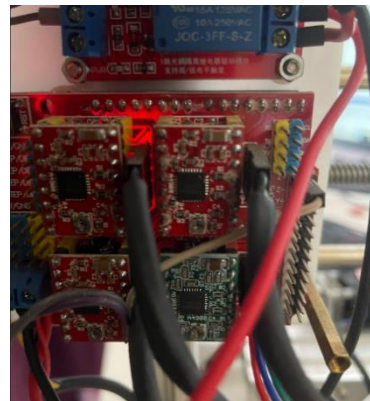
Fig. 6 Engine connection

Fig. 7 Result paper

Fig. 8 Metal result

6. Marketing

Figure 9 shows on the map several legal entities located near the headquarters where the processing procedures are carried out, namely the Polytechnic University, as can be seen the products made by the CNC System are intended in principle for those who want to make or own objects custom or at least non-mass produced items.

Several legal entities located near the headquarters were selected and the distance between the Polytechnic University and each merchant was calculated and an attempt was made to estimate the cost of transporting the product through two courier companies.

• Raimar deals with the customization of watches, it is located in the City of Bucharest, Bulevardul Iuliu Maniu 546-560, the distance from the Politehnica University is 6 km; the transport cost is (15 lei – Fan Courier; 18 lei Cragus);

• Malvensky deals with jewelry customization and is located at a distance of 5.6 km from the Politehnica University in Bucharest, 46 Lascăr Catargiu Boulevard; the transport cost is (12 lei – Fan Courier; 13 lei Cragus);

• Happy Gift deals with the customization of glass, plastic and metal objects and is located in Bucharest at a distance of 8 km from the Politehnica University, Str. Alexandru cel Bun no. 43, the cost of transport is (19 lei – Fan Courier; 20 lei Cragus).
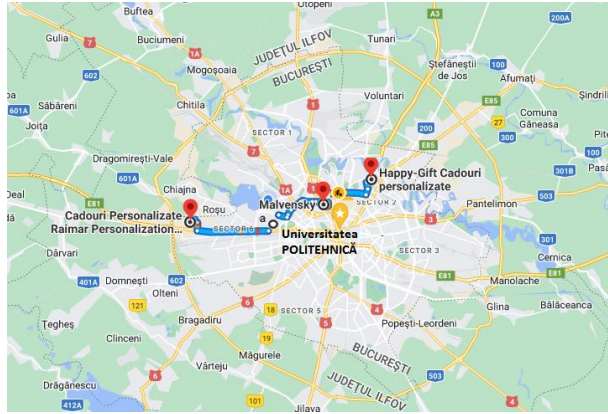
Fig. 9 Representation on the map of possible customers

Therefore, as a possible customer, any person can be considered because we encounter these procedures applied to the products we use at every step.

7. Economic analysis

The calculation presented below helps to determine the number of parts (critical number) from which it becomes profitable to use laser instead of milling.

The parameters Ai and Bi are calculated with the relations presented below:

$$A_i = \frac{m_{sf} \cdot c_m + (1 + \frac{R_f}{100}) \frac{\tau_{buc}}{60} s_{mi} + \frac{\tau_{buc}}{60} \frac{c_{MU}}{F_n}}{} \quad (1)$$

$$A_1 = 7.66*25 + (1 + \frac{170\%}{100})* \frac{10}{60} * 5 + \frac{10}{60} * \frac{400}{992} = 192.41 \; €$$

$$A_2 = 4.25*20 + (1 + \frac{150\%}{100})* \frac{5}{60} * 3 + \frac{5}{60} * \frac{500}{1984} = 85.27 \; €$$

$$B_i = C_{SDV} * \frac{a+j}{100} \quad (2)$$

$$B_1 = 500 * \frac{100\%+25\%}{100} = 6.25 \; €$$

$$B_2 = 600 * \frac{100\%+20\%}{100} = 7.2 \; €$$

In the case of two variants of carrying out an operation, the relations of manufacturing costs are as follows:

$$C_{xi} = A_i \; x + B_i \; = C_{x1} = 192.41 * 1 + 6.25 = 198.66 \; € \quad (3)$$

$$C_{xi} = A_i \; x + B_i \; = C_{x2} = 85.27 * 1 + 7.2 = 92.47 \; € \quad (4)$$

The critical number of parts x_{cr}, from which a variant starts to become more economical than another variant is determined by equalizing the corresponding costs according to the relations:

$$x_{cr} = (B_2 - B_1) / (A_1 - A_2) = (7.2 - 6.25) / (192.41 - 85.27) = 0.00887 \; buc \quad (5)$$

The total workload is the workload required for activity k of the research-development process and is calculated using the following relationship:

$$V_{M \; CD} = 100 + (\sum Ni * ki) *1*1.2*0.35 = 247 \; ore \quad (6)$$

The design labor cost is determined by the formula below:

$$C_{MAN} \; = V_{M \; CD} \cdot Smh = 247 \; [ore] * 3.5 \; [RON/oră] = 864.5 \; [RON] \quad (7)$$

The CAS social insurance contribution is represented in relation 8:

$$CAS = 10 \; \% * C_{MAN} = 86.45 \; [RON] \quad (8)$$

The calculation of the cost at the level of the design workshop is carried out with the help of relation 9:

$$C_{AP} = C_{MAN} + C_{MAT} + CAS + C_{GAP} \quad (9)$$

$$C_{AP} = 864.5 + 500 + 86.45 + 380.38 = 1831.33 \; [RON]$$

Expenses with indirect remuneration and administrative expenses with design activities can be found in the relationship below :

$$C_{GAP} = R_{AP} \ (\ C_{MAN} + \text{CAS} \ ) = 0{,}4 \ (\ 864.5 + 86.45)= 380.38 \ \text{RON} \ (10)$$

The determination of the total design cost will be done using the relationship:

$$C_{cp} = C_{AP} + C_D + C_{AT} = 1831.33 + 27.47 + 18.31 \approx = 1877.11 \ \text{RON} \ (11)$$

The expenses for the technical assistance are related 12 :

$$C_{AT} = [\ 0{,}01\ldots0{,}05 \ ] \ C_{AP} = 0{,}01 * 1831.33 = 18.31 \ \text{RON} \ (12)$$

Selling expenses are represented in the relationship below:

$$C_D = [\ 0{,}01\ldots0{,}03 \ ] \ C_{AP} = 0{,}015 * 1831.33 = 27.47 \ \text{RON} \ (13)$$

Calculation of the partial cost of the technological project:

$$C_{cp} = C'_T * C_{cp} = 0{,}9 * 1877.11 = 1689.4 \ \text{RON} \ (14)$$

The calculation of the cost of the technology project is found in the relationship :

$$C_T * = C'_T + C_m + C_{ast} = 0.9 + 0.045 + 0.045 = 0.99 \ \text{RON} \ (15)$$

Technical assistance costs:

$$C_{ast} = C_m = 0{,}05 \ C'_T = 0{,}05 * 0.9 = 0.045 \ \text{RON} \ (16)$$

The unit price or price proposal is calculated according to the relationship:

$$\text{P} = C_P + P_r = 2800 + 280 = 3080 \text{lei} \ (17)$$

The selling price is calculated with the relationship below:

$$P_v = \text{P} + \text{TVA} = 3080 + 739.2 = 3819.2 \ \text{lei} \ (18)$$

The technical time norm is calculated, considering the final preparation time $\tau\_$pî=10 min. The other components of the technical time norm are determined according to the basic time (τ_b) and the effective time (τ_{ef}) according to the following formulas valid in this case:

$$\tau_{dt} = 5 \ \% \ \tau_b = 5 \ \% * 120 = 6 \ [\text{min/buc}] \ (19)$$

$$\tau_{do} = 2 \ \% \ \tau_{ef} = 2\%(\ \tau_b + \tau_a \ ) = 2 \ \% \ \tau_{ef} = 2\%(\ \tau_b + \tau_a \ ) = 2\% * 60 = 1.2 \ [\text{min/buc}] \ (20)$$

$$\tau_{on} = 0{,}5 \ \% \ \tau_{ef} = 0{,}5 \ \% \ (\tau_b + \tau_a \ ) = 0{,}5 \ \% \ \tau_{ef} =$$
$$= 0{,}5 \ \% \ (\tau_b + \tau_a \ ) = 0.5 \ \% * 60 = 0.3 [\text{min/buc}] \ (21)$$

The above calculations were performed between a milling machine and an engraving machine. Therefore, the CNC System for engraving and microtexturing is an advantageous product having one of the lowest prices on the market in relation to the quality.

8. Conclusion

In conclusion, following the research on the market of CNC devices, we can say that we have the most cost-effective product quality price that can satisfy the wishes of all users.

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