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CREATING A CNC EXPERIMENTAL PROTOTYPE LASER USING RECYCLABLE MATERIALS FOR MECHANICAL PARTS

Dan Ovidiu GLAVAN, Emil-Calin KAZOMIR, Theoharis BABANATSAS

Abstract: *The paper aims to provide an idea of how to build a CNC laser from recyclable materials to create design by wood pyrography. To convert images into CNC commands line CNC Benbox Laser Engraver was used. To build the mechanical part old computer parts were recycled for cost reduction at the minimum on constructive functional architecture. For the computational part were used the motors from two recycled dvd-roms, an Arduino UNO board, an Arduino CNC Shield board, two controllers for the stepper motors, relay, power cable, data transmission cable from the laptop.*

Key words: *CNC laser, pyrography, Arduino, laser engraver, programmable microcontroller, mechatronics system.*

1. INTRODUCTION

The discovery through research of materials with advanced characteristics, but also the requirements of parts of high complexity has led to the emergence through research of new processing technologies called unconventional technologies [1] including laser processing.

The laser was first used in 1965 to drill into diamond molds but CNC pyrography first appeared only around 1990 [2]. Due to its spectacular development laser technology is used today in armament building, medicine, industry but also for engraving and design pyrography.

The processing of materials in order to obtain finished parts can be done by various technological processing methods. Plastic deformation procedures, cutting processes but also by more modern processes called unconventional processing technologies or advanced processing processes (electro-erosion, electrochemical, chemical, electron beam, laser, plasma, jet, ultrasound etc.) [3].

Laser technology is widely used for cutting, drilling, engraving, pyrography, marking, welding, sintering and heat treatment. Laser processing is a process by which the tool does not come into direct contact with the material to be processed, however it influences it thermally but not considerably and only in the cutting area [4]. The material melts, burns, vaporizes or is removed, resulting a very good quality surface [5, 6]. The surface quality or roughness represents the totality of the roughness's left by the tool on the processed material. These are most commonly measured in Ra or Rz.

Ra- is the quadratic mean deviation and represents the arithmetic mean of the absolute deviations of the profile from the midline within the limits of the baseline length.

Rz- the arithmetic mean of the heights of the irregularities in ten points.

The values range for profile roughness Ra is between 0.008 μm and 400 μm. Industry preferred values are: 0.012; 0.025; 2,050; 0.100; 0.20; 0.40; 0.80; 1.60; 3.2; 6; 3; 12; 5; 25; 50; 100.

It also has medical applications in dental or general operations, dermatology, endoscopy, urology, neurosurgery medical equipment [7] and others [8].

The basic principle of laser consists in uniform local heating and melting of the material to be processed on a certain depth [9, 10], with removal of material by sublimation and ablation [11], this process may require multiple work steps [12]. In the case of wood the

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removal of material is done by burning and ablation.

Before deciding the technological process of manufacturing the parts it is always necessary to analyze which is the cheapest technology through the customer's requirements can be met because any technology has its limits.

The laser engraving machine is used to engrave different images on several types of materials.

Although laser machines have high prices, operating costs make this technology cost-effective due to high productivity, relatively low production costs, no need for highly qualified operators, high accuracy .

Lots of materials like: wood, textile materials, glass, coated metals, ceramics, leather/ synthetic leather, marble, paper, rubber, wood veneer, painted metals, unpainted light metals, plastic, cork, aluminum, stainless steel, brass titanium and others can be laser graved.

In this context, CNC Laser processing depends on several parameters such as laser power, distance between nozzle and work piece, cutting speed, assistant cutting gas, type and thickness of the material, etc. Roughness can be highly improved by increasing the cutting speed and decreasing the gas pressure [1].

The pyrogravure width figure 1, is extremely narrow (0.02 to 0.025 mm). Highly detailed work can be carried out without the restrictions of a minimum internal radius imposed by milling machines and similar mechanical methods.

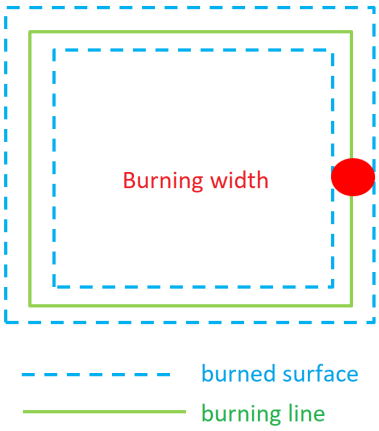

Fig. 1. Burning width**.**

2. MATERIALS

This part presents the construction of an experimental CNC Laser. Only recycled parts were used for the mechanical design : frame, legs, fixed sleepers, motherboards, stepper motors.

This CNC laser will have only two translation axes being intended for 2D pyrography. The laser source has a power of 250 mV. Machine tools have a complex construction specific to the machining process they perform. The construction comprises fixed and movable elements. The fixed components of the CNC laser are: frame, legs, fixed sleepers, motherboards. The moving parts of the model are the tables.

The frame is the basic fixed component and it takes over the mechanical stresses of the machine tool.

In this case the frame is composed of 4 rigidly mounted parts: steel support from one monitor (two pieces part recycled) and two clad wooden boards shown in figure 2.

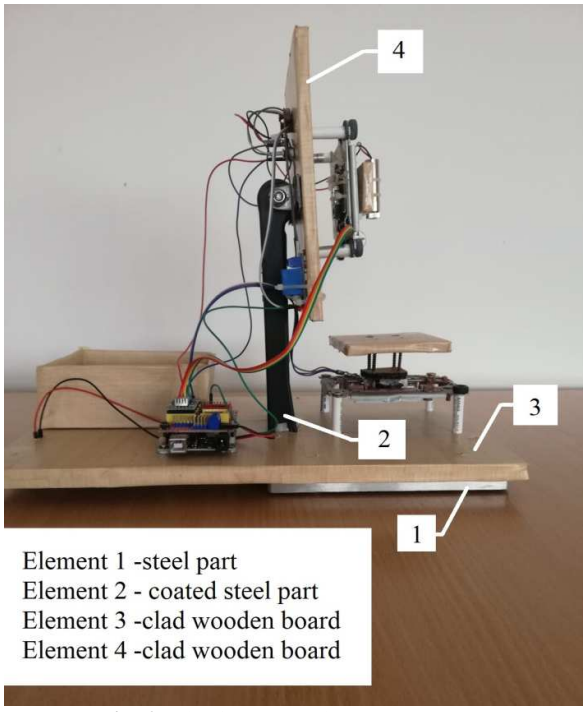

Fig. 2. The frame and its scope

The size of the frame was chosen taking into account the size and weight of the work pieces,

subassemblies it supports and the kinematic structure of the machine tool [13].

The base plate support legs are also recycled elements from writing instruments through which the base plate fixing screws passes into the frame.

For motherboards and fixed sleepers recycled elements of two old DVD-ROMs were used, figure 3.

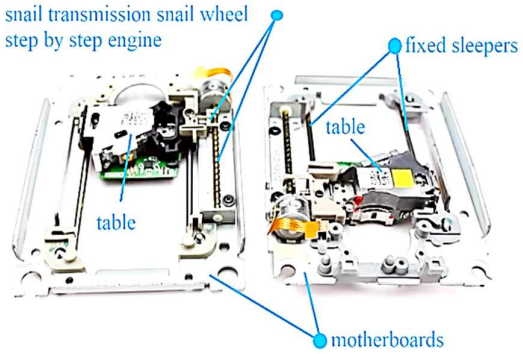

Fig. 3. Motherboards

The tables were adapted to this application even there are already tables in the recycled DVD-ROMs but the pieces and laser could not be fixed on them because they are too small and too low and this fact would lead to collisions. The tables have been adjusted as in the picture below figure 4.

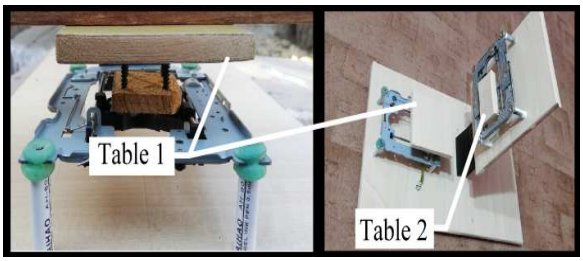

Fig. 4. Tables

The pieces to be processed will be attached to table 1 and a low power laser will be mounted on table 2.

The engines and transmission of DVD-ROMs will be used because they are sufficiently precise. The transmission is snail-wheel type and transforms the rotational motion of the engine into translational motion. Thus with the two axes covered by the two engines the machine tool will be able to process flat parts. The snail-wheel transmission ensures a quiet and uniform movement on long and very long runs, allowing for strong reduction and accuracy of its movements. The snail is usually made from steel, in this case from plastic, and the snail wheel made of anti-friction material: bronze or cast iron. These elements demands a pretentious execution and requires abundant lubrication. In this case they are recycled from DVD-ROMs, figure 3.

3. METHODOLOGY

For the computational part were used the stepper motors from two DVD-ROMs, an Arduino UNO board, an CNC Shield board, two controllers for the stepper motors, figure 5, one relay, power cable, data transmission cable on the laptop, and for the control of the CNC laser the Benbox Laser Engraver software was used.

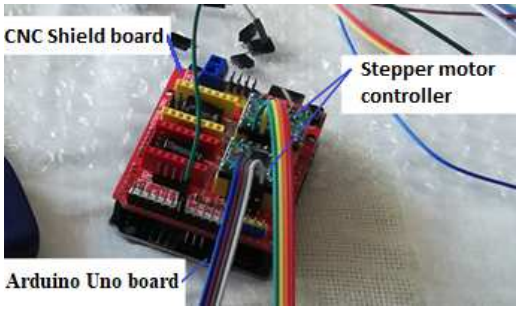

Fig. 5. Arduino setup

The Arduino UNO board is a microcontroller board based on an ATmega328 microchip. The Arduino UNO board does not generate enough power, it only transmits control pulses between the computer and the CNC Shield board, the two boards being mounted together as in figure 5 having an identical pin configuration. CNC Shield supports up to 36V power, but it was only power with 7V because the stepper motors can not operate at such power. Even stepper controllers can't carry such power. Jumpers will be used for step subdivisions.

On the CNC Shield 4 stepper motors can be connected. However in this case only the stepper motors for the x and y axis are necessary, z axis in not required because the laser technology has the advantage that the processing tool does not come into physical contact with the work piece. The Z will be a fixed distance and will be

crossed by the laser beam. No rotational axis needed.

The CNC Shield board should not be power supplied before connecting the stepper motors, otherwise the controllers will burn almost instantly. To protect the controllers the power was adjusted to 0 from the potentiometer.

On stepper controllers, a radiator must be mounted. The ones mounted by gluing created some problems because they did not properly take over the heat resulting in thermal shut down of the stepper controllers. So for better heat pick-up, the glue was removed and conductive paste used for computers processor was placed instead. The conductive paste hardens itself and acts like a glue. After mounting on the radiator, the connection to the stepper motors and the power supply will adjust from the potentiometer the amount of power depending on how much stepper motors were build for with a multimeter.

Benbox Laser Engraver software was used to control the CNC laser. It is a program that is able to recognize color pixel by pixel and convert the image into code lines.

After installing the program, the desired operating language can be selected via the flag icon in the upper left. After selecting the serial port the firmware update button is the next to press to load the program to be executed in the Arduino UNO board.

The program allows to upload the .jpg photo extension or create new ones with a few given tools. Before start the program the origin has to be set, coordinates 00/00 like in figure 6.

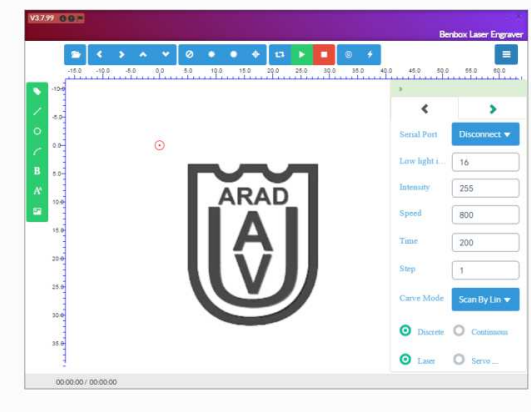

Fig. 6. First pyrographed part

The electrical circuit requires circuit nodes. Due to the fact that the wires are difficult to tin, the connectivity of the modules was achieved by using a test plate as a support, this is visible in the system connection diagram, figure 7.

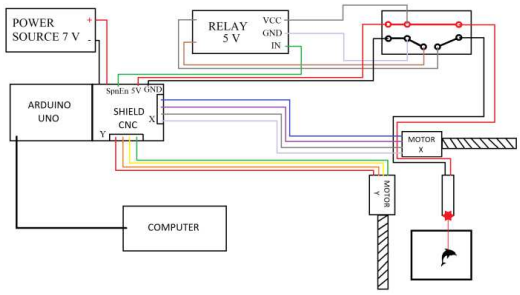

Fig. 7. System connection diagram

4. EXPERIMENTAL RESULTS

The CNC laser amounts to the initial expectations. It is very fast and easy to mount, and when it comes to use once adjusted and calibrated it does not require a highly qualified operator.

This machine has very few safety features but enough to be safe. In the rules of labor protection on laser machines it is specified that in the case of very low-power lasers the protective glasses are sufficient. As a matter of principle, laser machines are closed machines, but in this case this is not mandatory.

It was noticed that when the machine is powered and connect to the USB, the laser if not adjusted will work by default at full power, which is in this case wanted. However, for increased safety, discrete mode can be selected during the program setting period.

Given the price at which this CNC laser was built it meets the condition of price-quality ratio. A CNC laser of the same size consists about 200 euro [14] and this one was built at 40 euro. The physical cost consisted of laser source and Arduino modules, and the rest of the components, frame, motherboard, sleepers, stepper motors were recycled.

The idea of building this CNC by recycling parts came about due to the trend in recent years to have an environment as environmentally friendly as possible, with as little waste as possible that is not biodegradable and renewable [15].

In order to run a program with the CNC Laser, it must be connected to a computer. The serial port is automatically recognized by the Benbox Laser Engraver program otherwise it can be manually selected. The image is inserted inside the graduated rulers as can be seen in fig. 6 and can be scaled depending on the size of the part to be pyrogravated. After setting the parameters and the 0 point for the laser, the loaded program is ready to run. In this case was chosen a speed of 40mm/ min due to the fact that the laser is of low power. For a good pyrogravation, the size of the laser point must be adjusted as small as possible, focused. Figure 8 (8.a., 8.b. and 8.c.) presents the experimental obtain results.

Fig. 8.a. Romanian coat of arms

Fig. 8.b. University „ AUREL VLAICU of ARAD'' logo

Fig. 8.c. A dolphin

Fig. 8 d.) Gear wheel

5. CONCLUSION

The cost efficiency of laser technology is obvious, and its application sphere is broad in industrial applications and beyond.

Gradual software and hardware improvements are visible from the emergence of technology and will ensure the continuous success of the process.

The ability of laser technology to process materials with advanced characteristics, parts of high complexity (microparts or parts of high thickness), production flexibility, the possibility of processing multiple types of materials, the precision of execution and the high quality of the processed surface made this technology extremely attractive.

The built CNC laser amounts to the initial expectations. The print size is 52/52 mm and has a high accuracy. It is an open time machine and requires as a protective measure according to the rules of labor protection wearing laser goggles and operating only by trained personnel.

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CREAREA UNUI PROTOTIP EXPERIMENTAL CNC LASER UTILIZÂND MATERIALE RECICLABILE LA PĂRȚILE MECANICE

Rezumat: Lucrarea își propune să ofere o idee despre se construiește un laser CNC pentru a crea design prin pirografie pe lemn. Pentru a converti imaginile în linii de comenzi CNC a fost utilizat CNC Benbox Laser Gravator. Pentru a construi partea mecanică piesele vechi ale computerului au fost reciclate pentru reducerea costurilor la minim pentru arhitectura constructive funcțională. Pentru partea computațională s-au folosit motoarele de la două DVD-ROM-uri, o placă Arduino UNO, o placă Arduino CNC Shield, două controlere pentru motoarele pas cu pas, releu, cablu de alimentare, cablu de transmisie date de la laptop.

Dan Ovidiu GLAVAN, Conf. Dr. Eng., "Aurel Vlaicu" University Arad, Faculty of Engineering, Department of Automation, Industrial engineering, Textile production and Transport, E-mail: glavan@fortuna.com.ro, Phone: 0257-283010.
Emil Calin KAZOMIR, Mechatronic Design Engineer. "Joyson Safety System" Arad, Faculty of Engineering, Department Machine Building Technology, E-mail: kazomir.emil@gmail.com, Phone: 0755-940137.
Theoharis BABANATSAS, Lector, Dr. Eng., "Aurel Vlaicu" University Arad, Faculty of Engineering, Department of Automation, Industrial engineering, Textile production and Transport, E-mail: babanatsas@outlook.com, Phone: 0257-283010.