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LOW COST MULTIFUNCTIONAL CNC LASER AND MILL BUILT FROM THE REUSE OF COMPUTER EQUIPMENT AND E-WASTE: REM-CNC ROUTER

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Abstract: CNC machines are widely used in automated industries making the production process faster and more efficient. In addition, these machines have a high cost, making this technology inaccessible to a large part of the population. Thus, this work describes the process of building a multipurpose CNC machine with reduced cost through the reuse of recycled materials. Called REM-CNC Router, this CNC machine has the ability to operate in two different ways, allowing the engraving of images on the surface of materials by means of a laser, and the machining of printed circuit boards, 2D parts and even 3D, using a milling cutter. Produced from recycled materials, in addition to stimulating the reuse of e-waste, recycling of materials and encouraging the DIY culture, it has a reduced cost, making it a CNC machine with a great cost benefit and production quality.
Keywords: CNC Machine, Reuse, Recycle, E-waste.

INTRODUCTION

In recent decades, technological advances have allowed the replacement of manually operated machine tools by automated machine tools. According to Leite et al. (2017), this process began around 1949, with the emergence of NC technology (*Numeric Comands*, or Numerical Commands), which a posteriori was called CNC (*Computer Numerical Comands*, or Computer Numerical Command). The first CNC machine was developed at the Massachusetts Institute of Technology (MIT) and only became popular around 1982, a decade after the expansion in the industrial sectors, where it was widespread among medium-sized companies due to the introduction of cost-effective computers. reduced in its automated processes (LEITE et al., 2017).

Later, this technology became known as *Computer Numerical Control*, allowing the control of the movement and operation of machine tools, having as main advantages the reduction of cost, production time, efficiency, agility, flexibility and precision (VERMA; GIANCHANDANI; SAROHA, 2018).

With such advances, new industrial requirements have emerged such as increased production rates, product accuracy, quality and cost reduction. Thus, only with the use of CNC technology these requirements can be met, since these automated processes do not have human limitations and are able to manufacture highly accurate products at nanometer scales much more efficiently (JAYACHANDRAIAH et al., 2014).

Currently, CNC technology is widely used in industries, increasing the precision and quality of products, in addition to allowing the manufacture of extremely complex parts in an agile and efficient way. However, having a very high cost, this technology becomes difficult to access for most people. However, with the high dissemination of information on the internet and the popularization of *DIY (do it yourself)* culture, several projects based on CNC technology used in large industries began to emerge, making it accessible and allowing free access to this technology (DANTAS; JUNIOR, 2016).

According to César and Bonilla (2007), the cost of developing projects involving robotics and automation is very high, making them unfeasible for the majority of the population. In this context, César and Bonilla (2007) use sustainable consumption cited by Morigi and Jesus (2020), where the adoption of the 3R's is evidenced, on which the development of education focused on Reduction is based, aimed at consumption only of what is necessary ; for Reuse, where everything that is consumed can be reused and for Recycling, where any product can be reintroduced into the production system, generating new products. Based on these principles, it is proven that through the reuse and recycling of computer and electronics materials, robotic systems can be built with minimal or even negligible costs.

This way, the motivation for the construction of a medium-sized multifunctional CNC machine using recycled materials called REM-CNC *Router (Recycled Material-CNC Router)* emerged. Possessing the ability to operate a cutter and a laser non-simultaneously, the REM-CNC Router can be used for making printed circuit boards, machining 2D and even 3D parts with low complexity, laser engraving and cutting, and can even be used to print 3D objects by adding an extruder to the Z axis of the machine, allowing the manufacture of a range of professional quality products in less time and at a reduced cost, in addition to reducing impacts on the environment. because it is built reusing electronic waste and other materials.

METHODOLOGY

Originally developed by Walendorff (2020), the Homemade CNC 2.1 *Arduino* project with Low Cost Telescopic Drawer Rails by Marlon Nardi Walendorff, under Creative Commons Attribution-NonCommercial 4.0 International License, has become the main reference for the project. and development of the REM-CNC Router.

Through the analysis of Walendorff's project (2020) and taking into account that the project proposal was already low-cost, it was realized that there would be a greater cost reduction if the replacement of commercially acquired parts and materials were carried out with materials. recycled and in good condition for the CNC machine to be built.

This way, it was possible to make several changes to the original design by Walendorff

(2020) in order to obtain an increase in the work area of the REM-CNC Router, in addition to allowing the easy change of the tool used in the machine. Verma, Gianchandani and Saroha (2018) state in their study that the use of waste materials from computing devices and e-waste for the construction of robotics and automation projects causes great cost reduction, improves the cost-effectiveness and reduction of environmental impacts.

THEORETICAL FOUNDATION

TYPES OF CNC MACHINES

A CNC machine is any electronic equipment that guides tools along tracks arranged in a Cartesian coordinate plane. Such machines carry out the movement of the tool in the Cartesian plane through geometric information inserted in a system, which can start from the starting point of the machine's work or from the initial coordinate of a part (GOBI, 2019).

These movements start from the interpretation of the information contained in the G-code file performed by the machine, and may vary according to the type of tool that the machine is operating, such as a laser or a micro grinder (POLASTRINI, 2016). The great differential of the REM-CNC *Router* compared to conventional CNC's is the possibility of operating in two different ways, being like a CNC *router* or a CNC laser, allowing the exchange of functions in a simple and compact way.

According to Polastrini (2016), a CNC Router is a machine designed to perform operations such as milling and drilling in low-density materials such as wood, aluminum alloys and polymers, with priority being given to the traction force and the speed of tool displacement on the axes. of the Cartesian plane, which may vary according to the material to be worked. Its way of operation consists of fixing the material to the work table, which has fixed rails on its sides that allow the mobility and stability of the X axis displacement set. Perpendicular to the X axis, a second segment of rails is positioned responsible for the displacement of the X axis. Y axis, where rails are positioned vertically allowing the movement of the tool coupled to the Z axis.

A CNC laser, on the other hand, has the same characteristics as a CNC *router,* being differentiated only by the absence of the Z axis and by the use of a *laser* module instead of a *spindle.* This machine is capable of making cuts or engravings on the contact surface of various materials, only determined by the power of the laser reflected on the material being worked on. Commonly, these machines have only the X and Y axes, and their priority is the tool displacement speed (POLASTRINI, 2016).

HARDWARE

The *hardware* is one of the main elements responsible for controlling the displacement of the axes in the Cartesian plane based on instructions received from a software. There are several types of hardware capable of performing these functions depending on the needs of your *application*, such as PLCs (Programmable Logic Controllers) (ARTACHO, 2015) and Microcontrollers (RODRIGUES; KALIL, 2013).

One of the most used microcontrollers in the DIY community (do it yourself) is the Atmel® AVR®, which is part of the Arduino® electronic prototyping board, which makes it the most viable option to be used in the construction of the REM- CNC Router, as it has a relatively low cost, free hardware and software and a variety of boards with different models that can be used according to the needs of each project (PALMIERE, 2016).

Arduino® UNO REV3

For this project, the Arduino® UNO REV3 with ATmega328P microcontroller (ARRAHMAN, 2022) was used, whose function is to receive the G-code sent by the software through the USB port, interpret it and activate the actuators that command the movement of the tool in the movement axes (POLASTRINI, 2016). In addition, Arduino has a wide range of ready-made codes and libraries that are made available by communities linked to the platform, and can be changed by users with high-level language programming knowledge (GOBI, 2019).

CNC Shield V3

The CNC *Shield* V3 is a module compatible with Arduino® UNO REV3 and has input and output connections for controlling components such as Stepper Motor, Endstops, Spindle and others. Widely used for CNC machines and 3D printers, the CNC Shield is controlled by a *firmware* that is stored in the Arduino® memory, which is responsible for converting the G-code into the movement of the stepper motors connected to it (ANIS; SANTOSA, 2019).

According to Polastrini (2016), the main benefits of using the CNC *Shield* V3 are its simplicity of electronic installation, the arrangement of fittings for the direct connection of up to four power drivers and an independent power input for these drivers, which can vary from 12V to 35V.

Power Drivers

The A4988 driver, because it is easy to operate, allows the control of stepper motors that have a bipolar drive, and is built with MOSFET, it is one of the most used drivers in the development of CNC machines and 3D printers (MOREIRA, 2018). According to Moreira (2018), these types of drivers are essential to control stepper motors so that accuracy, torque and adequate operating speed are guaranteed. In addition to having an adaptive current system, which allows controlling the maximum current output through a potentiometer on the driver itself, it is possible to adjust the voltage sufficient to allow the motor to reach higher speeds without risk of damage, operating at up to five levels. resolution being full pitch, 1/2 pitch, 1/4 pitch, 1/8 pitch and 1/16 pitch.

STEP ENGINE

According to Moreira (2018), the use of stepper motors in projects like this is crucial because they have high torque, synchronism, rotation angle and precise positioning. A stepper motor has two parts: a stator and a rotor. The stator is composed of coils that connect to the motor terminals, while the rotor is composed of copper coils connected opposite each other. When the motor senses electricity, it causes the rotor to rotate between different directions. This is caused by electrical pulses that spin the rotor in several directions at once. Each pulse rotates the rotor a quarter of a turn before stopping, creating what is called a pitch.

SOFTWARES

The software is responsible for the interface between the user and the machine, allowing the control and manipulation of its actions through an intuitive and easy-to-operate graphical interface (FACHIM, 2013). Called CAM (Computer-Aided Manufacturing), these software are widely used by CNC machines, providing the instructions that must be followed by the machine to start and complete the manufacturing process of a particular product. There are several types of open source CAM software that have compatibility with Grbl (G-code interpreter), which can be used to control and configure G-code (MOREIRA, 2018).

Firmware GRBL

The Grbl firmware is a G-code interpreter created by Simen Svale Skogsrud in 2009, and because it is open source, it is widely used by the DIY community (FACHIM, 2013). It is free software developed in C language and optimized to be used in conjunction with ATmega328p microcontrollers, being one of those responsible for controlling the machine's movements, it has a GPLv3 license, requires simple hardware and has industrial standards, becoming the basis for CNC machines, 3D printers and other three-axis machines (POLASTRINI, 2016).

G-Code

Following a pattern, CNC machines use commands composed of lines of instructions called blocks, which are formed by words that have letters and numbers. This standard, called the G Code, is defined by the ISO 6983.1 standard and is composed of two basic categories of functions, the preparatory functions (G), whose role is to indicate to the machine tool how it must operate, leaving it ready to perform. movements, and miscellaneous functions that are complementary to preparatory functions and generally act as programmable switches for machine components such as spindles, motors and other auxiliary systems (REZENDE et al., 2019).

Arduino IDE

Acronym for Integrated Development Environment or Integrated Development Environment, the Arduino® IDE is a multiplatform software that was developed in Java language, responsible for automating tasks such as debugging, compiling and sending compiled binary to the Arduino® electronic board microcontroller. The language used to program in this software is a variation of the C language based on Wiring (FRIZZARIN, 2016). In addition to being cross-platform, which allows it to run on different operating systems, the Arduino® IDE is easy to operate, allowing beginners and advanced users to develop projects, and can be expanded through C++ libraries (ARDUINO, 2018).

Universal Gcodesender Universal Gcode Sender

In order to communicate between the computer and the machine, it is essential to use software that sends the set of instructions that the firmware will read and execute. There are several software that the user can choose to perform this function, such as Easel, bCNC and Universal GcodeSender. Developed in Java under the GPLv3 license, Universal GcodeSender is compatible with several operating systems such as Windows®, Linux and Raspberry, being easy to configure and the most used. Universal GcodeSender only reads the G-code and sends it to the CNC machine, not having support for creating or editing G-code instructions (POLASTRINI, 2016).

LaserGRBL

LaserGRBL is a free software capable of generating and transmitting G-code commands and trajectory to Arduino® directly, through an internal conversion tool that the software has. Unlike other GUI (Graphical User Interface), LaserGRBL was developed for use with hobbist laser cutter and engraver, in addition to having compatibility with Grbl v0.9 and Grbl v1.1 firmware (LASERGRBL, 2020).

RECYCLING AND REUSE OF WASTE AND ELECTRONIC MATERIALS

The increase in humanity's quality of life through technological and scientific advances has brought with it major side effects, such

as increased consumption of goods, rampant use of inputs and increased generation of electronic waste and pollution (OBANA et al., 2018a).

Electronic waste (e-wast) represents the fastest growing solid waste in the world, becoming one of the biggest problems, especially in developing countries, where most of this waste that has non-biodegradable toxic substances in its composition is generated (DUARTE et al., 2020).

According to data presented by *The Global E-wast Monitor* 2020, in 2019 South America produced approximately 4 Mt (Megatons) of e-waste, of which Brazil was responsible for the production of 2143 kt (Kilotons), reaching the mark of 10.2 kg per capita per year (FORTI et al., 2020). Of this total, Brazil recycles only about 17% of electronic material, a very low amount when compared to countries such as Germany (80%) and Japan (60%) (OBANA et al., 2021). According to Obana et al. (2021), population awareness is a crucial factor for these data, since the first laws for solid waste management appeared in Japan in 1954 and today it is already part of the Japanese routine. In Brazil, this type of policy was only implemented in 2010 with the approval of Law No. 12,305/10, which establishes the National Solid Waste Policy (PNRS) (OBANA et al., 2021).

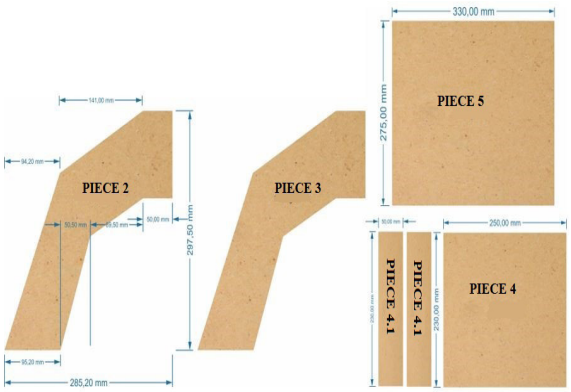
With this perspective, the Laboratory of Electronics and Embedded Systems (LESE) of the Bachelor's Degree in Computer Science at UNEMAT's Alto Araguaia Campus was founded as a space where various teaching, research and extension activities are carried out, where since 2015, the Project Reuse and Recycling of Electrical and Electronic Equipment (PRREE) (OBANA et al., 2018b).

In addition to LESE, the Center for Recycling and Innovation in Automation and Robotics (CRIAR) was also founded in 2020, which acts as a technological, administrative, financial and legal consultant for entrepreneurial, innovative, research and extension projects. CRIAR currently assists projects that work with the recycling and reuse of electronic equipment, developing electronic devices for robotics, automation and educational robotics.

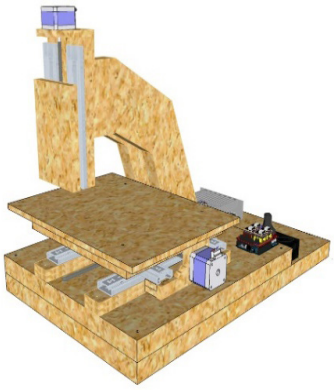
Through LESE and CRIAR, several devices were developed, totally or partially built with recycled materials and electronic equipment, among which we can highlight the Flexible LED Panel, Biometric Lock, multifunctional CNC (mill and laser), 3D printer built with recycled and spherical robot, demonstrating that the recycling and reuse of computer equipment in automation and robotics projects bring great benefits to the environment, in addition to reducing the costs of these projects.

DEVELOPMENT

Initially, for this project, a study was carried out based on the instructions provided by Walendorff (2020), which provides all the assembly steps, from the physical structure to the mechanics and electronics, of a low-cost CNC machine. From this, a survey of viable parts and components that could be used for the execution of this project was carried out, considering that the objective of this work is to reduce costs in the construction of CNC machines through the reuse of recycled material. The acquisition of the necessary mechanical and electronic components took place through the Recycling is Transforming Project: Electronics and Robotics with electronic waste (OBANA et al., 2021), which allowed a reduction in the construction costs of the CNC machine. During the analysis of the Walendorff project (2020) and the REM-CNC Router project, some materials were replaced and some physical structures were changed, to increase the stability and work area of the CNC machine (Figure 1).



(a)



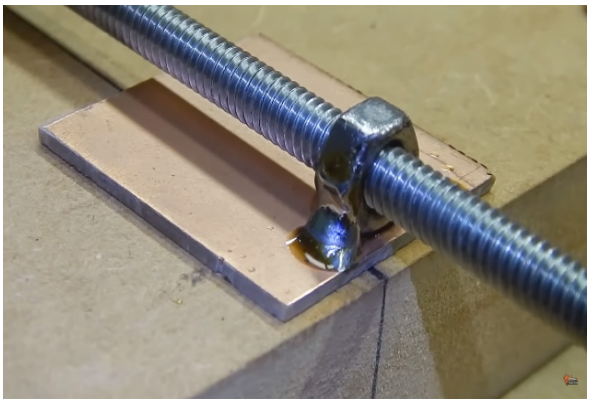
(b)

Figure 1. Modifications of the REM-CNC Router – (a) Modeling and Resizing of the parts, (b) 3D model of the prototype.

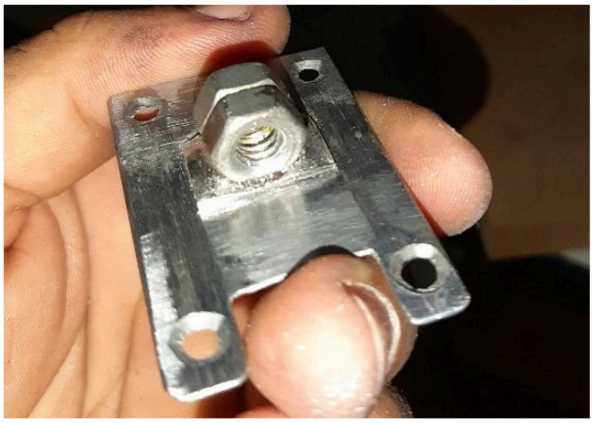
Source: Author (2022).

Taking as a reference the measurements of the pieces available by Walendorff (2020), a base in MDF with measurements of 350x550x30 mm was manufactured to couple on Piece 1 of the original project, also made of MDF with a thickness of 30 mm, allowing greater stability during the machine operation. In order to increase the work area of the REM-CNC Router, the measurements of parts 2, 3 and 4 of the original project were changed, respectively generating new parts that can be analyzed in figure 1(a).

Such modifications allowed the REM-CNC Router's working area to be changed from 200x200 mm to 250x250 mm. In addition to these structural changes, changes were made in the mechanical part aiming at greater durability of the equipment. Analyzing the project by Walendorff (2020), it was noticed that, during the preparation of the telescopic rails, there would be a discard of metallic material from the cutting of the rails. This residual material was used to replace the phenolite plate used to build the spindle coupling for moving the X and Y axes (Figure 2(b)).



(a)



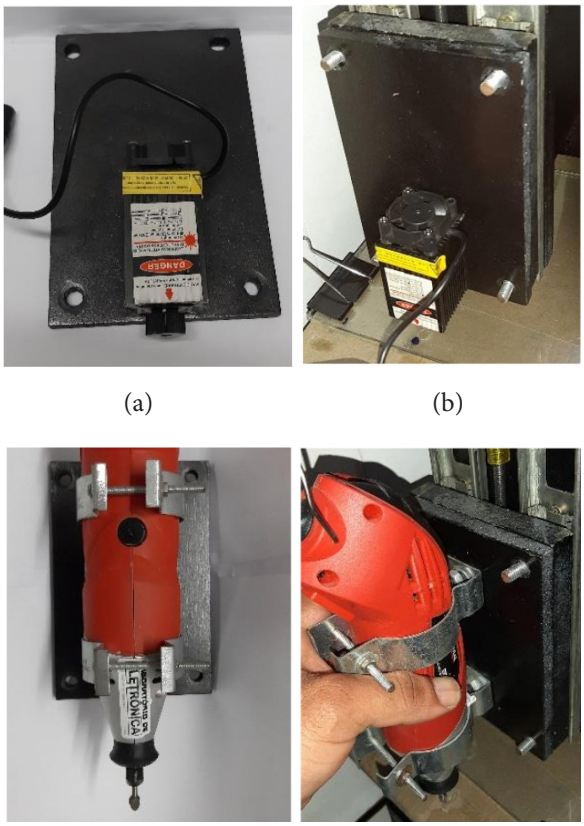
(b)

Figure 2. Threaded Bar Coupling Part – (a) Original design part made with phenolite board, (b) Adapted part made with leftover telescopic rail.

Source: Author (2022).

Another modification carried out based on the original project was the replacement of the heat-shrinkable spaghetti, used as a threaded rod motor shaft coupler, for a

silicone gasoline hose, allowing greater flexibility and durability. In addition, four ¼-inch hex screws were added to each corner of part 6 to fix the machine tool in a simple and easy way, considering that the CNC machine was built to be used with a milling machine and a laser. non-simultaneously.



(a) (b)

(c) (d)

Figure 3. Coupling the REM-CNC Router tool modules – (a) Laser Module, (b) Laser Module coupled to the shaft, (c) Milling Module, (d) Milling Module coupled to the shaft.

Source: Author (2022)

COSTS

To demonstrate and validate the feasibility of reducing costs in the use of recycled materials, it was necessary to analyze the costs employed by this project compared to the projects of Walendorff (2020), Moreira (2018) and Dantas; Junior (2016) illustrated in Tables 1, 2, 3 and 4.

Items	Quantity	Subtotal
NEMA 17 stepper motors with torque equal to or greater than 2.5kgf.cm.	3	R$ 180,00
Source 12VDC x 5[a]	1	R$ 22,00
Rectifies the same or similar eccofer AR172	1	R$ 130,00
0.25 mm diameter wire. It will depend on how you ride. (subway)	20	R$ 9,00
Arduino uno + cable.	1	R$ 60,00
CNC Shield V3.0	1	R$ 25,00
A4988 stepper motor drive	3	R$ 55,00
1/4 threaded bar (meter)	1	R$ 12,00
Heat shrink spaghetti 9.5 mm in diameter (meter)	0,5	R$ 5,00
Nuts for 1/4 threaded bar	3	R$ 2,00
Light drawer telescopic rails 25 cm	6	R$ 40,00
Relay module to control the grinding	1	R$ 10,00
Limit Switch KW11-7-1 16A 250VAC with 60mm Rod	6	R$ 20,00
PCI 5 cm x 5 cm	2	R$ 3,00
MDF pieces cut in joinery (board value + labor)	-	R$ 100,00
Superb thread screw M5x50mm	8	R$ 1,00
Superb thread screw M3.5x30mm	9	R$ 1,00
Superb thread screw M4x16mm	18	R$ 1,00
M3x16mm screw (for stepper motors)	8	R$ 1,00
Alley inside diameter 3mm outside 10mm	16	R$ 1,00
L-type metal angle bracket 2 holes 13x13mm	2	R$ 2,00
20mm diameter circular felt foot	4	R$ 2,00
TOTAL COST VALUE		R$ 682,00

Table 1. Walendorff CNC cost table (2020).

Source:(WALENDORFF, 2020).

Items	Quantity	Subtotal
Physical structure	1	R$ 249,00
Micro Grinder AWT Red	1	R$ 249,00
Raspberry Pi3	1	R$ 220,00
Power Supply (24V 15A)	1	R$ 80,00
Stepper Motors (Used)	3	R$ 50,00
Driver A4988	3	R$ 33,00
Arduino UNO	1	R$ 25,00
Telescopic Rails	6	R$ 34,00
Pulley Gt2 5mm	1	R$ 14,90
GTt2 pulley 6.35mm	1	R$ 14,90
Belt Gt2 400mm	1	R$ 14,90
50mm diameter metal clamps	1	R$ 8,00
1/4 thread bar	1	R$ 4,00
Nuts of ¼	6	R$ 2,00
Screws 60mm x 4mm	2	R$ 0,40
Screws 80mm x 4mm	2	R$ 0,40
Screws 40mm x 4mm	4	R$ 0,60
Screws 14mm x 4mm	25	R$ 2,50
flexible engine coupler	2	R$ 29,80
Milling cutter 60º 0.1mm	1	R$ 14,90
20cm x 20cm phenolite board	1	R$ 12,00
TOTAL COST VALUE		R$ 1.059,30

Table 2. Moreira CNC cost table (2018).

Source:(MOREIRA, 2018)

Items	Quantity	Subtotal
CNC Shield	1	R$ 5,23
Driver A4988	3	R$ 13,26
NEMA 17 Stepper Motor	3	R$ 115,14
Arduino UNO	1	R$ 12,81
Industrial Switching Power Supply 60W 12V 5A	1	R$ 48,30
1/4 (meter) threaded bar	2	R$ 12,60
Nuts of ¼	3	R$ 0,30
Light Telescopic Rail (pair)	3	R$ 20,10
Micro Rectify	1	R$ 229,00
Accordion coupler	3	R$ 10,92
TOTAL COST VALUE		R$ 467,66

Table 3. Dantas CNC cost table; Junior (2016).

Source:(DANTAS; JUNIOR, 2016).

Items	Quantity	Subtotal
Physical Structure (MDF pieces cut in the joinery)	1	R$ 165,00
Arduino UNO REV3	1	R$ 35,70
CNC Shield	1	R$ 17,90
White grease	1	R$ 5,00
Telescopic rail 25cm (pair)	2	R$ 60,00
Instant Adhesive 793 TEKBOND	1	R$ 10,00
Driver A4988	3	R$ 26,10
NEMA 17 Stepper Motor	3	Recycled
Source Bematech Mp20 Fr20 Ft2997 - 24V	1	Recycled
Relay Module	1	Recycled
1/4 Threaded Bar (meter)	1	R$ 2,30
3.5x30mm wood screw	8	R$ 0,80
3x30mm wood screw	4	R$ 0,40
3.5x25mm wood screw	2	R$ 0,20
Wood screw 6x65mm	12	R$ 6,00
4x20mm wood screw	4	R$ 0,20
3.5x20mm wood screw	14	R$ 0,70
3x16mm wood screw	10	R$ 0,50
Wood screw 4.5x25mm	4	R$ 0,40
Hex Screw Zinc Plated UNC 1/4"x1.1/4"	4	R$ 1,20
Hex Screw 6x50mm	2	R$ 0,80
6mm nut	2	R$ 0,10
1/4 nut	6	R$ 0,60
1/4 butterfly nut	4	R$ 2,80
Gasoline hose (meter)	1	R$ 5,00
Inca Clamp Type D2	2	R$ 10,00
Blue Laser Module 2.54-3p 500mw Eleksmaker	1	R$ 211,16
Micro grinder Hammer Mi-150K 150W 127V 60Hz	1	R$ 161,00
TOTAL COST VALUE		R$ 723,86

Table 4. Project cost table REM-CNC *Router*, described in this work.

Source: Author (2022).

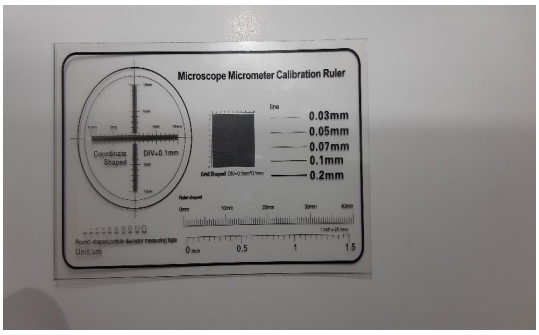
It can be noted in the data presented in the Cost Tables that there is a difference between the resources spent for the construction of a project based on Walendorff (2020), given that this value may vary according to the size of the work area, the types of of machine tools that will be used and how to use the CNC machine. In this case, the REM-CNC Router has the average cost among the others presented, but its ability to operate two tools differs from the others.

RESULTS AND DISCUSSIONS

At the end of the entire design, testing, adaptation and assembly process, always taking into account the cost reduction in relation to the original project, a low-cost CNC machine was obtained with part of the materials used coming from electronic waste and recycled materials, showing that there is great potential in the reuse of electronic waste in the construction of CNC machines. As a form of validation, the REM-CNC Router was used to make printed circuit boards and laser engraving on surfaces of some materials, demonstrating efficiency, in addition to being exposed at MT Sciences at Sesc in Cuiabá-MT and other events, demonstrating to the local community the importance of reusing materials for the construction of such projects, was used in the production of Face Shield type protective masks to assist in the fight against Covid-19.

The precision of the CNC machine was analyzed through some tests using the laser tool and a 3mm thick MDF board. Knowing the diameter of the laser beam coupled to the machine (0.05mm), 5 to 13 parallel lines per millimeter (mm) with 14 mm in length were traced (Figure 4a).

(a)



(b)

Figure 4. Test Analysis – (a) MDF board with laser engraved 5mm x 14mm rectangles, (b) Microscopic camera scale ruler.

Source: Author (2022).

Using a microscopic camera, the resolution and precision achieved by the REM-CNC *Router* were analyzed, where the highest precision achieved was 50 µm with a resolution of 100 µm, which can be analyzed in figure 5 with the scale based on the ruler. (500 µm) of figure 4(b).

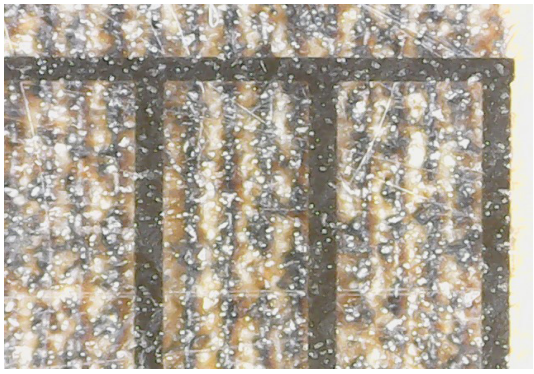


Figure 5. Enlarged image of MDF Board with laser engraved 5mm x 14mm rectangles.

Source: Author (2022).

CONCLUSIONS

Based on the results, we can say that the REM-CNC *Router* is a low-cost alternative to CNC machines with functionality similar to the others presented in this work. Its main advantage is the ability to operate both a Laser, capable of engraving on the surface of materials, and a Micro grinder, allowing engraving on the surface of materials, machining 2D and even 3D parts. Another advantage is its relatively larger working area when compared to similar ones found in the literature. The REM-CNC *Router* is a multifunctional CNC machine, built with recycled materials, with reduced cost and micrometric precision, proving that the use of these materials reduces the production costs of CNC machines.

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