An-Najah National University

Faculty of Engineering

Computer Engineering Department

GRADUATION PROJECT 2 (HardWare)

Arduino CNC Foam Cutting Machine

Prepared by :
Haya Khufash
Takreem Abdallah

Supervisor:
Dr.Asmaa Afifi

Presented in partial fulfillment of the requirements for Bachelor degree in (Computer Engineering).

25/12/2020

Contents

List of Figures

Table of Abbreviations:

CNC	**Compute Numerical Control**
UGS	**Universal G-Code Sender**

DISCLAIMER

This report was written by student Haya khufash and Takreem Abdallh at the Computer Engineering Department, Faculty of Engineering, An-Najah National University. It has not been altered or corrected, other than editorial corrections, as a result of assessment and it may contain language as well as content errors. The views expressed in it together with any outcomes and recommendations are solely those of the students . An-Najah National University accepts no responsibility or liability for the consequences of this report being used for a other purpose than the purpose for which it was commissioned.

Abstract

CNC machine is a numerical control using the computer , this machine can work in 3 axes and is characterized by high accuracy

In our day, There were many problems in making this machine because the tools were not enough to install it. We resorted to make this machine because the time that painters fade to paint a painting on wood or on foam are waste a lot of their time and sometimes the picture that was drawn is not of high quality for this .We turned to this project. The benefit of this machine ability to cut and shape foam . Foam in various shapes into square, triangular, cylindrical and polygonal shapes. It is used in private or public events and parties

The aim of this machine is to form different figures that are used in several works, such as molds for wood or iron. The main tool in this project is the hot wire that we can pass through a current and a specified voltage, and it can cut foam according to the required shape.

Acknowledgment

At the outset, I would like to thank the great doctor Dr.Asma Afifi who supervised us and who followed us during the project period and who provided us with ideas to facilitate the process of building the project. As well as our parents, family who provided us with moral and psychological support because of the current conditions in our country. They were a help to us during this period and they support that we lived during the Corona outbreak and the difficult circumstances we went through.

Chapter 1

Introduction

1.1 Statement of the problem

With all the developments we are experiencing and with modern technology. People are always working hard to improve their lives in various fields. And one of the areas that we are working to improve is the aspect of drawing or sculpting. Instead of using hand carving on foam, wood and other tools. This project we build a CNC machine that we can download any image we want , it works to cut it accurately and at the lowest price

1.2 Objectives of the work

This project goal is to build a CNC machine that can cut shapes with high accuracy, to connect them to the Arduino that controls these shapes, in order to obtain high performance and low cost

1.3 Scope of the work

This machine can use simply . Any person can use it to drawing .By add picture from pc using Arduino to the machine and draw it in a good way.

1.4 importance of the work

A small machine characterized by accuracy and ease of work. This machine have the ability to cut foam in several shapes like square, triangular, cylindrical and polygonal . It's used in private or public events and parties

1.5 Organization of the report

In the next chapter discusses constraints and earlier work .we will talking about the problems and obstacles that appear during this project

and the standards that we worked on it . And give some information about codes and previous courses related to our topic .

In third chapter discusses Literature Review and explains the similar systems to ours and the features that have been added to it.

In fourth chapter explains Methodology that we worked in project and the tools that were used to make it work in the required way.

In fifth chapter show the Results, Analysis and discussion the result of the work .

In Sixth chapter shows the problems that we faced, limitation of the project also the future plans for this project in order to improve it .

Chapter 2
Constraints and Earlier work

2.1 Constraints

There are many difficulties that we encountered during the construction period of the project:

1. The project is mostly mechanical, but we are computer students. We do not have sufficient working knowledge about mechanical matters in terms of installation and use of equipment, so it took more time than specified for our equipment and was able to accomplish.
2. The length of the aluminum profiles with the T slot was 60 cm. We took them to a carpenter who cut them with a metal hand saw to cut each to specific size. So it took more than once to be able to cut it . we encountered a problem during the installation It is larger than the size in the figure .

Figure 2.1 threaded rod Problem

3. At the top of the Y-axis rods a T slot was installed. We had difficulty 3D printing it broken due to the heavy load on it. We printed another piece with higher specifications

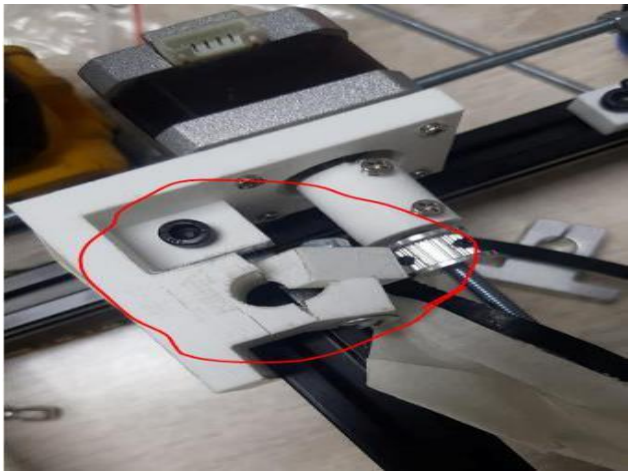

Figure 2.1.1 3D model problem

4. Because of the current conditions that we are going through .We have faced difficulties to meet with my partner because of the Corona virus that afflicted us and because of the closure that occurred after the completion of the electrical and mechanical work and the start of the test process. We faced many difficulties to go to the university Also, the size of the project was very large, so we kept it at the university .We could not take it home.

5. At testing period we faced a problem in Arduino CNC Shield , its burned so we replace it with other one .

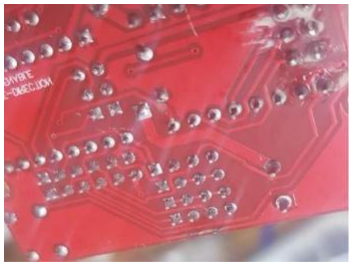

Figure 2.1.2 CNC Shield problem

2.2 Codes/Standard

At the first , we start from designing the machine, connecting the electronic components .Firmware to the Arduino which controls the motion of the machine. CNC machines is GRBL firmware so I put the grbl in Arduino library and work steps to Arduino knows how to read G-codes, how to control the machine according to them.

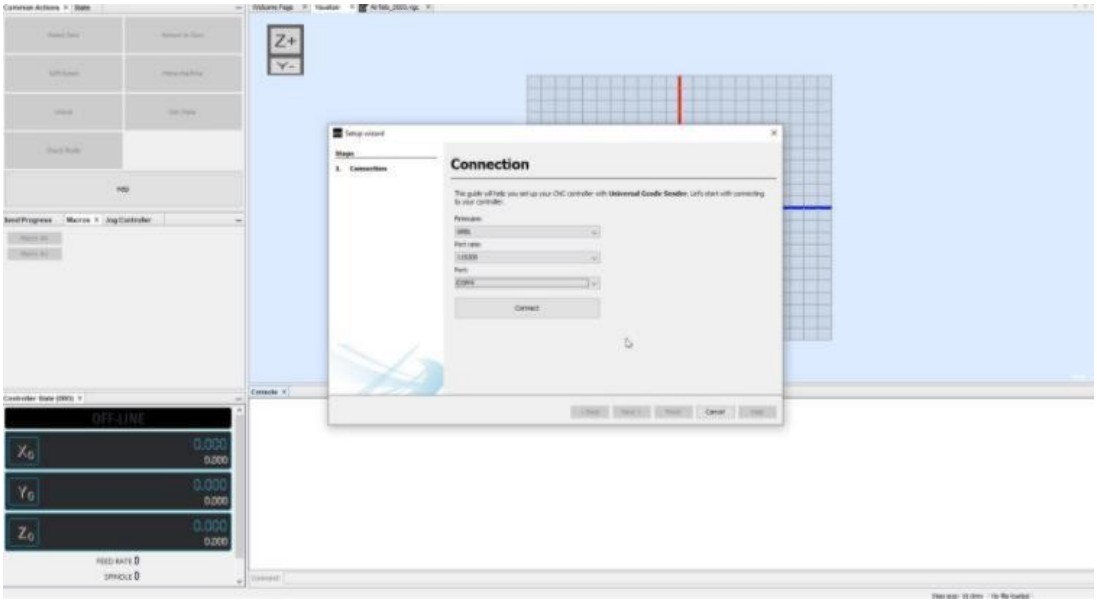

Figure 2.2 configure the machine.

2.3 Earlier Course work

Many courses that we have been taken that help us in the field of devices PIC, PIC lab, electronic and digital lab 3 that help us in controlling with a stepper motor, and online courses have been taken to learn about Arduino control.

Chapter 3

Literature Review

A lot of cutting machine was done in previous projects using several tools such as the pen, but the problem with pen that it's slips while it is raised. But our project is cutting and forming the appropriate shape using the hot wire.

First we installed the (X , Y , Z) axis for a special shapes so that we can control the movement of the hot wire , the G-code reads The drawing passes a point by point and takes the values of (X,Y,Z) from the drawing step by step by connecting the stepper motors to the shield and also 3 jumpers were placed at each motor to control the accuracy as it is 16 steps of a resolution .

The DC converter connected to the hot wire to control its temperature . We connect hot wire to springs via the Nuts M5 because the length of the wire is extended, and this springs solve this matter

We worked to install a piece in which a switch to turn on and off the hot wire through the power supply was given 12 volts, but a current passed through the hot wire connected to electrical wires . The hot wire after giving its voltage does not work and does not turn red, so we added other components that increase the voltage(boosting) ,it became working at 30 volts and passes through the current wire , the hot wire became red and can be cut to foam.

It is necessary that the bends of the belt should not be tight until the hot wire is moved and cut to the points specified for it through its image. And this is all during the installation.

At software part we first downloaded a frame work on the Arduino library in order to control the movement of the project which is GRBL . We choose the Arduino board and Com port.

We need an Interface to tell the Arduino what to do, it also sprouted to GRBL, which is the UGS Sender. First, we set the page size in this program according to the area in which our project works, and we downloaded an image , according to the Trace Bitmap feature, it converted the image into a vector image, we make the shape flow in a continuous form because this is a hot wire and not a pen that can be lifted and downloaded. And we click on G-Code and

through the Visualizer window, we can see the path that passes in any way it works and cuts the hot wire shape and how it moves from any point to any point.

Chapter 4

Methodology

4.1 Hardware Components

4.1.1 Overview

In this part we will mention the pieces that we used in our project and we will talk about the purpose of their use . one of the most important tool is hot wire ,which this part will draw in foam and that because this wire become hot when the current move in it and it will cut the foam in the requested way, all details will describe later.

- **T-slots**

The base tool here is T-slot aluminum profiles. This slot have many advantages one of them the easy way when you try to fix it you just need corner brackets to connect it with each other. Also if you finish the project you can easily disassemble it and use the part in other project. In order to cut them in the correct tall we used Metal saw.

Figure 4.1.1 T-slots side

- **threaded rod**

We use the threaded rod 2x50cm that will drive the belts, we cut it to the correct size and we passed it through the steeper, and we use nuts in order to fix them correctly

Figure4.1.2 threaded rod

- **3D printed items**

We have printed many of the plastic parts with excellent features using a 3D printer. We cannot use them from a previous project as previously with other tools because these are specific pieces and do not exist as individual parts .They support the project and install all the pieces using it and install some parts on them using bolts and nuts .These parts give the project a nice and tidy look, We printed it in white color as the figure shows.

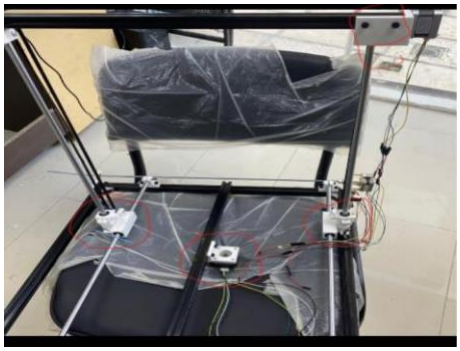

Figure 4.1.3 To show 3D model

- **Stepper Motor – NEMA 17**

In this project, we used 3 stepper motor to control x, y, z and because it has good specifications ,accuracy. Using the third stepper motor we will draw actually three-dimensional shapes using this machine, High Torque45Ncm

(63.7oz.in) holding torqueNEMA 17 bipolar 1.65 "x1.65" x1.57 "4-wire1.8 deg. Step angle (200 steps / rev) Rated current 2A & resistance 1.1ohms ,

We use Stepper motor because it more accurse and move in all side.

Figure 4.1.4 Stepper Motor

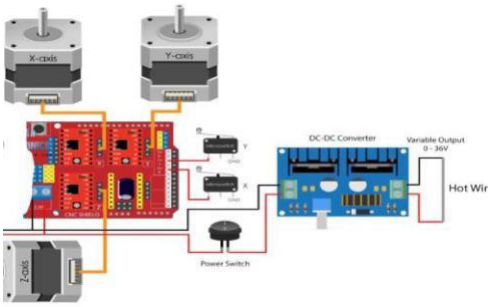

Figure 4.1.5 connections of stepper motor

- **Arduino CNC Shield**

We using stepper driver in order to specify the resolution that will the stepper driver use it to drive the motors and we use some jumpers .We use three jumpers for each drive so the resolution will be 16th step , That cause steppers to move in smooth ,connect 2 swt .

Figure 4.1.6 Arduino CNC Shield

- **GT2 Belt**

Figure 4.1.7 GT2 Belt

GT2 Belt is Helps with the movement of the hot wire in the X and Y to cut the proper shape **.**

- **Tooth Pulley**

We used tooth pulley to passed the GT2 Belt around it .

Figure 4.1.8 Tooth Pulley

- **Arduino Uno**

Arduino is a small computer that can interact and control its environment better than a desktop computer. Technically, it is an open source software platform consisting of a Micro-controller and an IDE. The strength of the Arduino is reflected in its great ability to communicate with electronic parts, its great effectiveness in controlling the motors , We use Uno because we have a little number of input , (serial from PC / 2 limit switch / 2driver from shield) .

Figure 4.1.9 Arduino Uno

- **Spacer Nuts and Bolts**

Figure 4.1.10 Spacer Nuts and Bolts

Many Nuts and bolts of different lengths M5 and M4 and lengths 13, 15 and 16 were used in order to fix the pieces to each other and the Nuts was fixed and made sure its tightness through the fittings with the same diameter of the Nuts.

- **Hot Wire**

The hot wire was used after connecting it between the axes and was connected with electrical wires to give it the appropriate voltage after giving them the appropriate power and the current passed through them and when given the appropriate voltage, it becomes red and can be cut on the foam

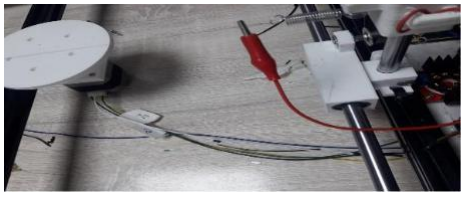

Figure 4.1.11 Hot Wire

- **Limit Switch**

We use limit switch to tells the computer the limit of CNC machine , it has three connection (GND , normally open , normally closed) connection.

Figure 4.1.12 Limit Switch

- **Bearing**

The bearing 2X5x16mm can reduce friction due to its shape, materials, and the presence of fluid between surfaces or by separating the surfaces with a magnetic field. Shape, as spherical or cylindrical shape gives the advantage of reducing friction, or by forming bending bearings. To reduce surface friction, it was used in this project for 3D pieces that were cylindrical in shape

Figure 4.1.13Bearing

- **A4988 Stepper Driver**

We use stepper driver to drive the motor using jumpers , in our project we use three jumpers with three stepper driver .

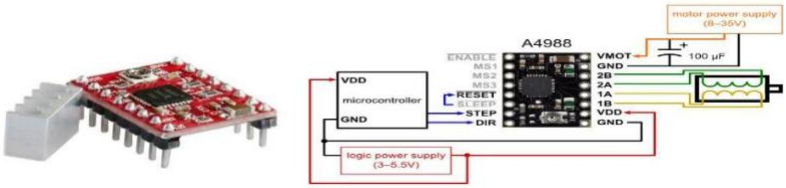

Figure 4.1.14 A4988 Stepper Driver

- **Foam**

Foam is the material that we used it to draw the shape that we need .

Figure 4.1.15 foam

4.2 Project structure

We will talk in this part about the way that we worked on it in this project . Our work contain two part (mechanical part , software part)

- **mechanical part:**

At the beginning we start with T-slot aluminum profiles which is 60-cm long. We use corner brackets in order to make the base frame .We need also M5 bolts and T-slot nuts for attaching all kind of things to them .

We continue connect all the component including 3D printed items in exact location and installed the belt in its place.

When we finished the base farm we can say that our project e can freely move in both the X and the Y axis.

After that we put the three stepper motor for the x-axis/y-axis/z-axis , then we attached GT2 belts for both side of x-axis and y-axis .

- **electrical part**

The Arduino Uno is a little input . Arduino Uno is connect wire between PC(USB port), it gives voltage or power by taking it from the PC, which is 5 volts. Of course, we put over the Arduino a piece named CNC Shield . This is put on cnc shield 3 drivers each drivers 2 input for Stepper Motors We installed 3 jammers to Resolutions for each driver. Also, we installed switches in X+ ,y+ and power supply, with a power of 12 volts to CNC shield .The other power wire we connected to the separate switch to controlling the hot wire (turn on/off), we gave the same voltage as 12v Then we go to DC converter controlling the temperature of hot wire. This Piece is useful for increasing the voltage by giving it .we put two wires From the power input.We checked through the voltmeter that it was given 12 volts. Then the input of DC converter is the 12 volt from wire power and the output is different from 0 to 35 . We checked the output with a voltmeter device .controlled the increase in voltage by wrapping the piece with a screwdriver ,we connected the output with two electric wires and clamping them to a handle for the hot wire.Hot wire became red after the arrival of 30 volts ,it make cut foam.

Here we connect CNC / 3D Printer shield through Arduino, then we connect Stepper Motor drivers through the shield, and we connect Stepper Motor drivers using suitable wires to the motors.

- **Software part :**

In the beginning, we used a firmware on the Arduino to control the movement of the device, which is one of the most common programs used it is GRBL firmware to put in Arduino library.

Figure 4.2.1 GRBL firmware

After that we need to use an interface or a controller in order to tell the Arduino what to do, and we also we used an open source called
Code S ender (UGS) Also G-code is a language in which people tell computerized machine tools how to make something, the most widely used digital control using computer. It is used mainly in computer aided manufacturing to control automatic machine tools.

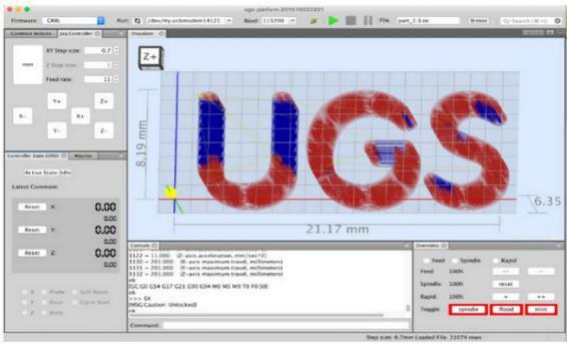

Figure 4.2.2 UGS-code

In UGS we need to select the suitable port and connect the program to frameware (GRBL), After the connection become true and make , and here we can check the direction of moving according to motors .

The final step here is to prepare the drawing which CNC can make shapes of them. According to that we will use an open source called Inkscape , In this program then we went to the setting and put the page measurements .We upload some photo .Then convert to vector image by Bitmap. We define it as a path, how to walk, we put Union.We put lines in the picture,so that the image is all interconnected with each other. So the hot wire can cut and connect them with some. Then we came to the G-code tools menue and we got the orientated point that X and Y so moves in them .After that we chose the shape that he is celinder, we put the Diameter is 1.We went to save path the G-code to open this in UGS.
On the UGS , there we open the G-Code that we sent on Extension npc through, to be ready and specific start point click the mouse this node and draw the shape on our project

.

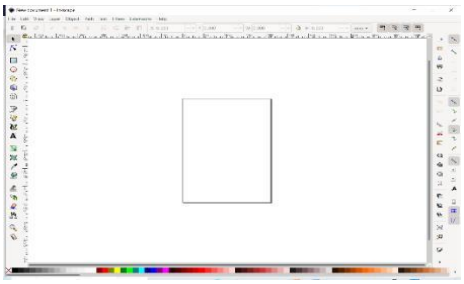

Figure 4.2.3 show Inkscape to draw

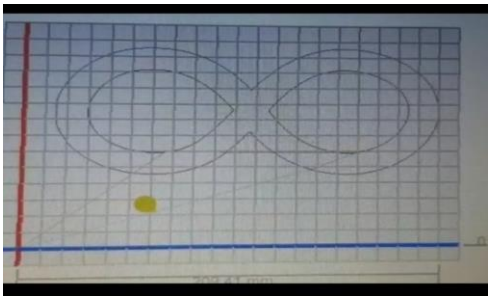

Figure 4.2.4 show UGS to draw

Figure 4.2.5 show Inkscape Gcode to draw

4.3 Components Cost

This component that we used in project :

ITEM	PRICE/UNIT	price per unit	Total Price
6x 20x20mm 500mm T-slot Aluminum Profiles	30	6	180
4x 10mm Linear Rails Rods 500mm	40	4	160
6x T-slot profile corner brackets	6	8	48
50x M5 nuts for T-slot Profiles	1	50	50
6x Linear bearings 10mm	30	6	180
GT2 Belt	18	5	90
Tooth Pulley	14	8	112
2x Bearing 5x16x5mm	7	2	14
Spacer Nuts	2	15	30
Spring	2	5	10
Hot wire	20	1	20
2x 50cm threaded rod	4	2	8
Bolts	50	1	50

Figure 4.3.1 Table of Project's components

ITEM	PRICE/UNIT	price per unit	Total Price
Arduino controller case	96	1	96
Foam tightener	15	3	45
Micro switches holder	9	1	9
Mounting bracket - Y-axis stepper v2	48	1	48
Shaft clamp 10mm	10	4	40
Shaft Coupler - 5mm to 5mm (v2 for 5mm pulleys)	5	1	5
Shaft Coupler - 5mm to 6mm	5	1	5
Sliding Block - X-axis 2	38	1	38
Sliding Block - X-axis	38	1	38
X-axis bracket 2	16	1	16
X-axis bracket 3 (v2 for 5mm pulleys)	16	1	16
X-axis bracket 3	17	1	17
X-axis stepper mounting bracket	23	1	23
Y-axis bracket 2 v2 (v2 for 5mm pulleys)	43	1	43
Y-axis bracket 2 v2	43	1	43
Y-axis sliding block 1	17	2	34
Z-axis motor mounting bracket	25	1	25
Z-axis platform	55	1	55

Figurer 4.3.2 Table of 3D Model

ITEM	PRICE/UNIT	price per unit	Total Pric
Stepper Motor – NEMA 17	20	3	60
A4988 Stepper Driver	20	3	60
Arduino CNC Shield	30	1	30
Arduino Uno	35	1	35
DC-DC Converter	20	1	20
Limit Switch	4	2	8
DC Power Supply	20	1	20
switch	4	1	4
		Total Price 1000	

Figure 4.3.3 Table of components for project

Chapter 5

Results, Analysis and Discussion

Thank God ,We completed the project and good results were obtained .The shape we want was obtained in the shortest possible time after many attempts. The hot wire was moved in several axes easily and without bends in the shape. This wire was cut out the shape that we downloaded G code and highlighted on the foam. The following pictures shows our project:

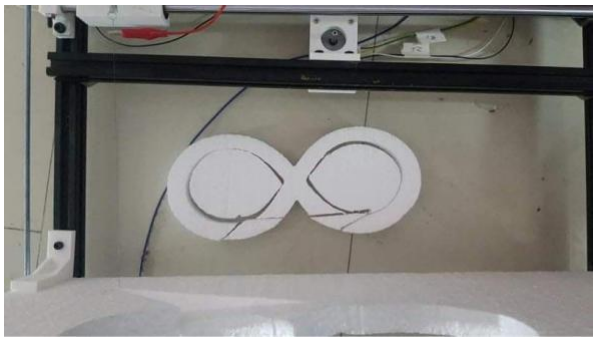

Figure 5.1.2 Result

Figure 5.1.3 our project

Figure 5.1.4 our project

Chapter 6

6.1 Summary

Our project is CNC machine which it use to cut the foam in simple way , this kind of project aims to facilitate and reduce the effort on people, this machine have high accuracy, high focus and also a great time to finish the draw . Our goal, first and last, is to facilitate human life and create new tools to help to him , and use the technology that we learned in the simplest things by uploading an image and following many steps to translate this image into G-code so that the motors and wires can move in clear steps.

6.2 Future Work

We hope in the future this project brings financial profit to us, or we develop it with more feature , One of the idea is to make it draw on wood .

Chapter 7

Bibliography

1. **Evans, Brian. *Beginning Arduino Programming*. Vol. 6. New York, NY, USA:: Apress, 2011.**

2. **Hasanien, H. M. (2011). FPGA implementation of adaptive ANN controller for speed regulation of permanent magnet stepper motor drives. *Energy Conversion and Management*, *52*(2), 1252-1257.**

3. **Suwandi, Herwani, and Septian Tri Setianto. "ANALISA SOFTWARE GRBL CONTROLLER UNTUK MESIN MINI CNC PLOTTER 3-AXIS DENGAN MENGGUNAKAN MIKRO KONTROLER ATMEGA 328." *TEKNOKOM* 2.1 (2019): 57-64.**

4. **Overby, Alan. *CNC machining handbook: building, programming, and implementation*. McGraw-Hill, Inc., 2010.**

5. **Xu, X. W., & Newman, S. T. (2006). Making CNC machine tools more open, interoperable and intelligent—a review of the technologies. *Computers in Industry*, *57*(2), 141-152.**