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Research Article

DESIGN AND IMPLEMENTATION OF CNC MACHINE USING AN ARDUINO

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ABSTRACT

Computer Numerical Control (CNC) machines are automated milling devices that make industrial components without direct human assistance. Using coded instructions that are sent to an internal computer, which allows factories to fabricate parts accurately and quickly. There are many different types of CNC machines, ranging from drills to plasma cutters, so can be used to make a wide variety of parts. Though most are used industrially in manufacturing. In this paper hardware and software parts are combined and engineered. They start with the computer that contain the application that design the specific component and the application that sends orders for machine, the controller kit that receive these orders and translate them into some kind of signals that goes into smart driver that translate them one more times and amplify them, finally these signals drive the motors that move the tool and make the work that needed.

INTRODUCTION

This section explains the general introduction and the theory needed in this paper.

CNC Machine

CNC is one in which the functions and motions of a machine tool are controlled by means of a prepared program containing coded alphanumeric data. CNC can control the motions of the work piece or tool, the input parameters such as feed, depth of cut, speed, and the functions such as turning spindle on/off, turning coolant on/off. There are many types of CNC machine .The common CNC machines are two -axis and three-axis .The two- axis machine can move on vertical and horizontal only which are X and Y axis. Three -axis machine can do movement starting with three primary axis which are X, Y and Z axis. The Z axis is being parallel with spindle (Frank *et al*, 2002).

The CNC machine operation starts with the collecting data from the programming that extract from computer-aided design (CAD) and computer-aided manufacturing (CAM).The programs produce the computer file and then will extract the command to operate the machine. The program will be transfer via post-processor and then be loaded into the CNC machine to start the machining .This is the flow of the CNC machine operation:

Figure 1 Flow of the CNC machine operation.

The CNC is a system. To complete the system of CNC machine, there are 4 components which are mechanical design, drives module, system software and Automatically Programming Tool (APT) postprocessor. For the mechanical design system, this part is the hardware part of the machine which is the part body. For the drive system, the command signal was received from microprocessor. Microprocessor is consisting of motors, amplifier units and a power supply .For the software system, it is generate the program to the CNC machine to start the movements of the tools and work piece. For the APT postprocessor, it was developed to produce the G-code and M-code that can be used by CNC machine.

Figure 2 Flow of CNC machine.

Besides that, CNC machine also include of wiring in order to connect the power to the machine. To complete the whole CNC machine, all elements must be in the good condition and must put at the right place (Nur S., 2012).

The applications of CNC include both for machine tool as well as non-machine tool areas. In the machine tool category, CNC

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is widely used for lathe, drill press, milling machine, grinding unit, laser, sheet-metal press working machine, tube bending machine etc. Highly automated machine tools such as turning center and machining center which change the cutting tools automatically under CNC control have been developed. In the non-machine tool category, CNC applications include welding machines (arc and resistance), coordinate measuring machine, electronic assembly, tape laying and filament winding machines for composites etc, Asif Hussain *et al*, 2016. The benefits of CNC are (1) high accuracy in manufacturing, (2) short production time, (3) greater manufacturing flexibility, (4) simpler fix Turing, (5) contour machining (2 to 5-axis machining), (6) reduced human error. The drawbacks include high cost, maintenance, and the requirement of skilled part programmer (Mike Lynch, 1996).

Design of CNC Machine

The CNC machine that be designed is three axis .it has required two main parts to complete, hardware and software part. The hardware part is divided into two sub parts, mechanical and electrical part.

Hardware part

The following two parts must be high accuracy to perform the work:

1. Mechanical part.
2. Electrical part.

Mechanical parts

The shape of the CNC and its measurements has designed by AutoCAD as shown in figure (3) and assembled from acrylic and aluminum sheets, this material has been chopped by industrial CNC machine for better accuracy.

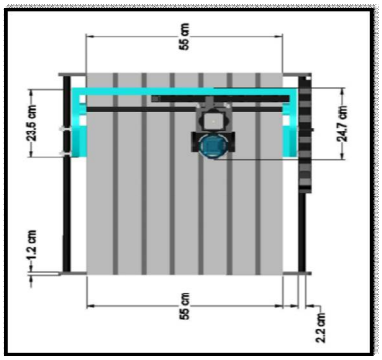


Figure 3 a top view.

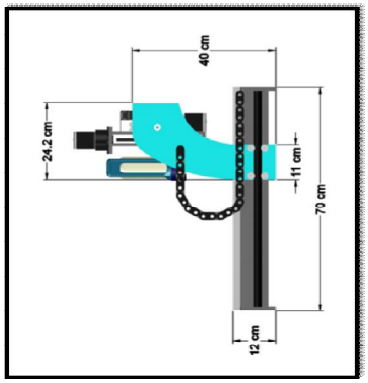


Figure 3-a upper view.

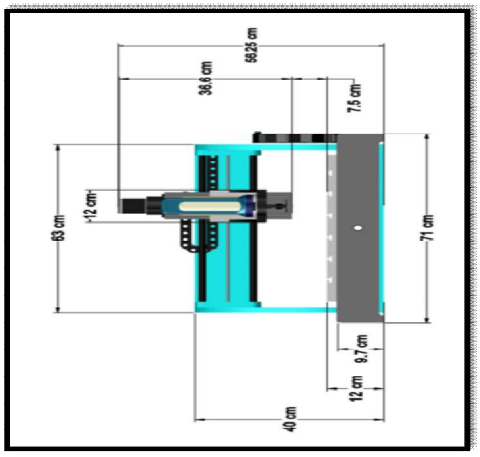


Figure 3 c front view.

The movement of the axis's

The linear motion system plays a vital role in any linear CNC machine, and CNC routers are no exception. Without these systems coupled with a drive system, a CNC router would be of little use.

it is a depend primarily on its axis's and its movement, so Z axis used lead screw as shown in figure(4) while X and Y axis used Serpentine Belt as shown in figure (5).

Figure 4 Serpentine Belt

Figure 5 lead screw.

Electrical parts

Electrical part consists of the following components as shown in figure (6):

1. 12 and 5 volt dc power supply
2. Arduino Uno microcontroller
3. Bluetooth module
4. Easy driver v4.4
5. L298n high bridge driver
6. Limit switch
7. Nema23 stepper motor
8. Spindle cutter machine

Arduino Uno microcontroller

Arduino/Genuine Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. Arduino is shown in figure (7).

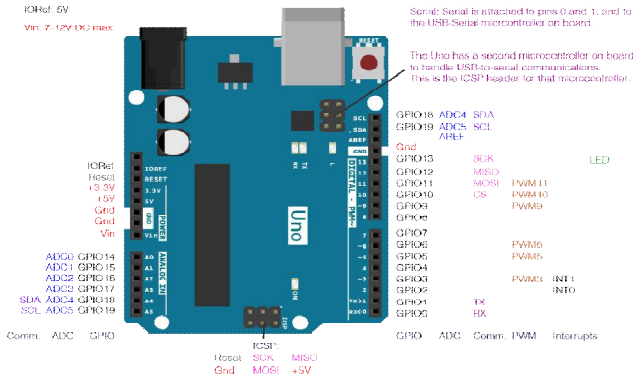


Figure 7 Arduino UNO.

Bluetooth module

Bluetooth is a wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz) from fixed and mobile devices and building personal area networks (PANs). Range is approximately 10 Meters (30 feet). Bluetooth module is shown in figure (8).

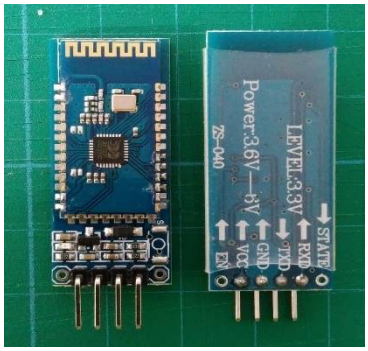


Figure 8 Bluetooth module.

Easy driver v4.4

The Easy Driver is a simple to use stepper motor driver, compatible with anything that can output a digital 0 to 5V pulse (or 0 to 3.3V pulse if you solder SJ2 closed on the Easy Driver). The Easy Driver requires a 6V to 30V supply to power the motor and can power any voltage of stepper motor. The Easy Driver has an on board voltage regulator for the digital interface that can be set to 5V or 3.3V. Connect a 4-wire stepper motor and a microcontroller and you've got precision motor control! Easy Driver drives bi-polar motors, and motors wired as bi-polar. I.e. 4,6, or 8 wire stepper motors. Figure(8) shows easy driver.

L298N High Bridge

The L298 is an integrated monolithic circuit in a 15- lead Multiwatt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage.

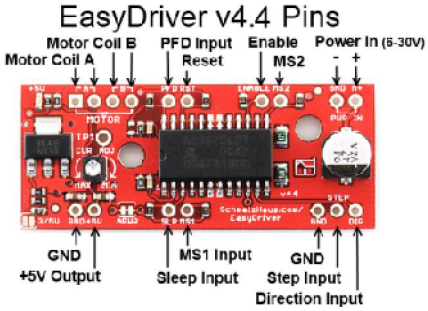


Figure 9 Easy driver V4.4.

Electrical mapping: The electrical mapping for interfacing a microcontroller with stepper motors of CNC is shown in figure (10).

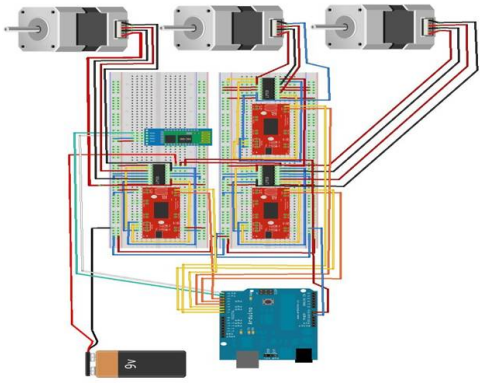


Figure 10 Electrical mapping of interface with CNC.

The circuit diagram for all system designed is shown in figure (11).

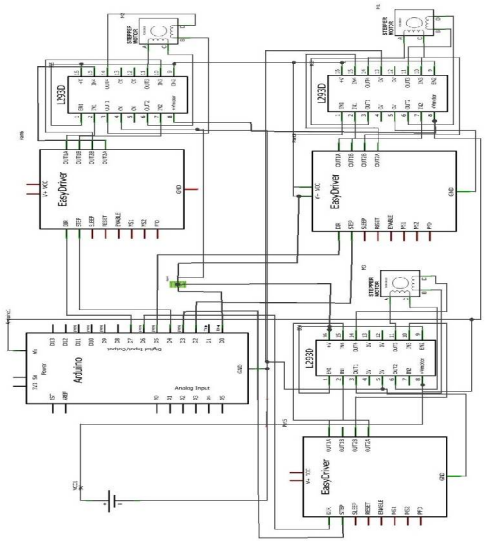


Figure 11 schematic diagram for all system.

Control box: The control box represent the electrical part that contains an arduino, drivers and Bluetooth module and other components which are used to interface with CNC machine.

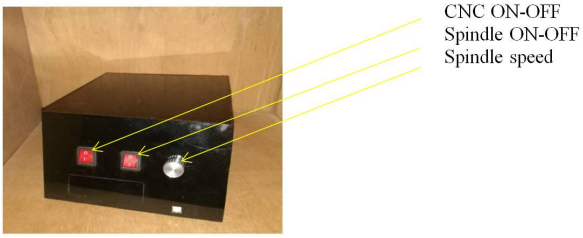


Figure 12 The control box.

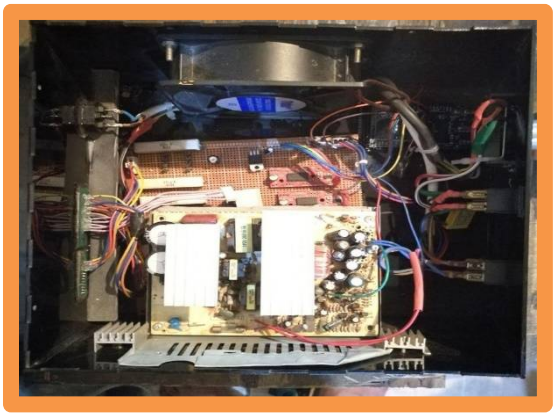


Figure 12 Internal view of control box.

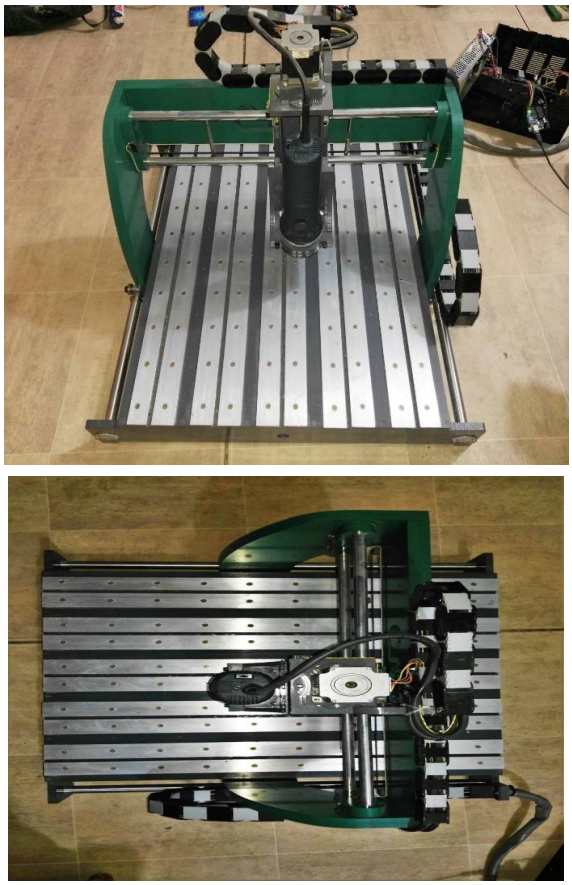


Figure 13 The designed CNC machine.

Software part

Software part consists of the following packages:

1. Drawing packages.
2. Machine control package.
3. CNC Programming.

Drawing packages: In this package draw the desired shape, such as Corel draw, ink scape and AutoCAD used to design 2d or 3d shapes and exports the drawing file as dxf extension or any extension accept by machine control package.

Machine control packages: such as bcnc imports the dxf file and simulate the work space for the CNC machine including the 2d or 3d shapes and the milling tool can be configured within this applications (Sheet CAM, bcnc) as required to chopping, engraving or carving the specific material.

Sheet CAM is a low cost but feature packed CAM package. it is suitable for milling, routing, plasma, waterjet, laser and oxy-fuel cutting.. Sheet CAM has many useful features for plasma, laser, waterjet and oxy-fuel cutting.

For machines that have full control over the Z axis you can program the pierce height and cut height directly. This is useful for machines running Mach3 for instance. SheetCAM combined with Mach3 and a torch height controller from C and CNC for an unbeatable plasma cutting solution.

GRBL CNC command sender, auto leveler and g-code editor. An advanced fully featured g-code sender for GRBL. bCNC is a cross platform program (Windows, Linux, Mac) written in python. The sender is robust and fast able to work nicely with old or slow hardware

Grbl Controller is designed to send G-Code to CNC machines, such as 3D milling machines. It isn't super smart; it just needs to give the user a nice way to get commands down to whatever controller they are using. Qt is pretty cool because you can create a nice GUI application for Windows, Mac and Linux.

CNC Programming

When programming CNC machine tools, the codes used are G-codes (preparatory functions), and M -codes (miscellaneous functions).

G-codes are sometimes called cycle codes because they refer to some action occurring on the X, Y, and/or Z axis of a machine tool. The G-codes are grouped into categories such as Group 01, containing codes G00, G01, G02, G03. Which cause some movement of the machine table or head. Group 03 includes either absolute or incremental programming, while Group 09 deals with canned cycles.

The G01, G02, and G03 codes move the axes at a controlled federate.

- G01 is used for straight-line movement (linear interpolation).
- G02 (clockwise) and G03 (counterclockwise) are used for arcs and circles (circular interpolation).

M or miscellaneous codes are used to either turn ON or OFF different functions which control certain machine tool operations.

M-codes are not grouped into categories, although several codes may control the same type of operations such as M03, M04, and M05 which control the machine tool spindle.

- M03 turns the spindle on clockwise

- M04 turns the spindle on counterclockwise
- M05 turns the spindle off

Simulation Work

The designed CNC can be used to perform two functions:

1. Plotter
2. Two dimensions cutting materials

Plotter: An example of (E) capital using ink skape, by selecting the object (E) and using the command "object to path" and save the file as (svg. Extension).

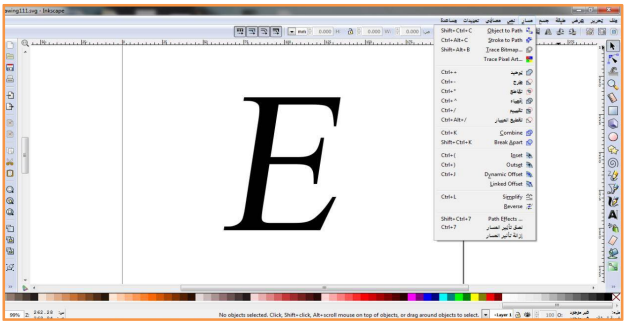
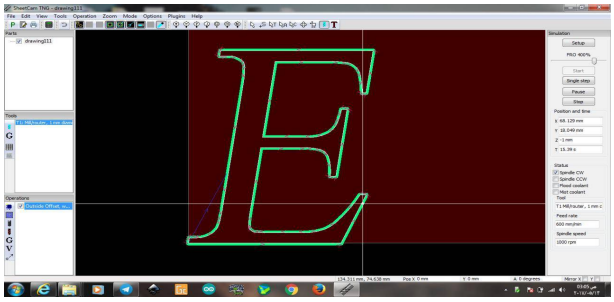
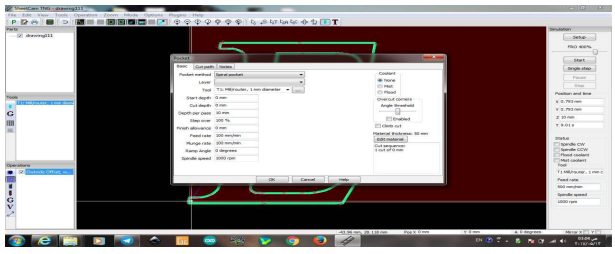


Figure 14 Using object to path command.

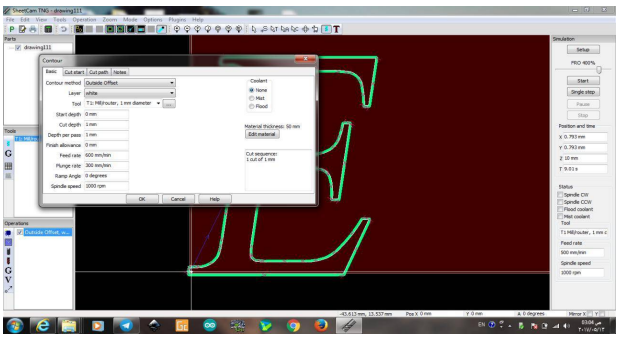
Then open the svg. File in sheet cam and edit setting as figures (15-a), (15-b),(15-c),(15-d) . Then save this file as G-Code extension.



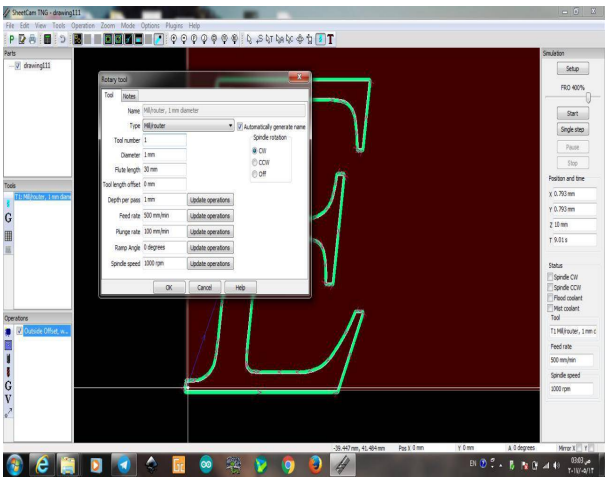
a



b



c



d

Figure 15-a, b,c,d Editing setting.

Then Open GrblControl, open the G-code file, connect the control box with computer, and set the zero, zero point and select the command "send".

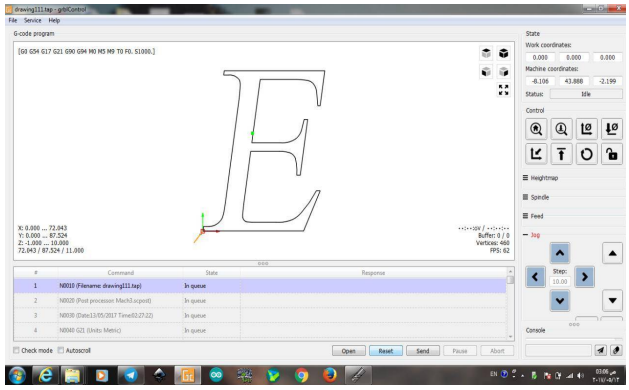
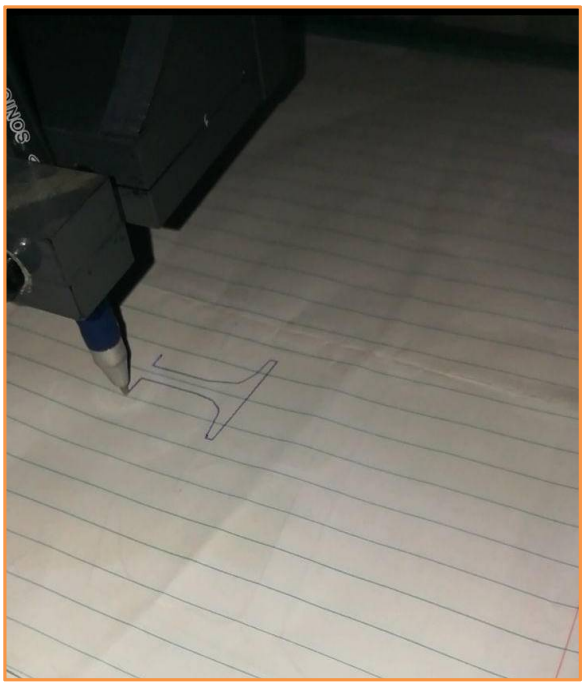
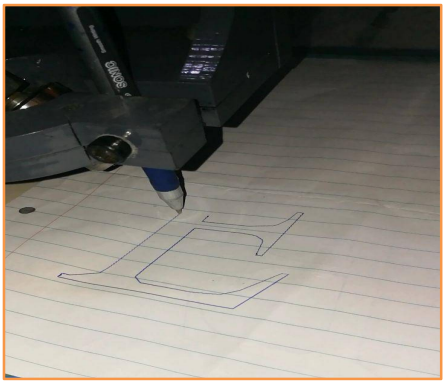


Figure 16 sending the g code file to CNC.

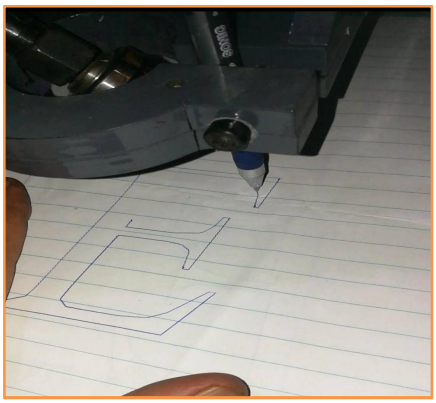
After that the CNC machine will work as follow:



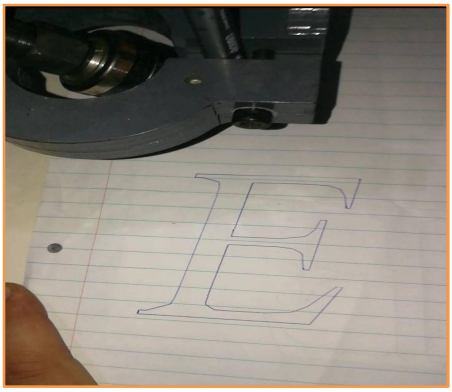
a



b



c

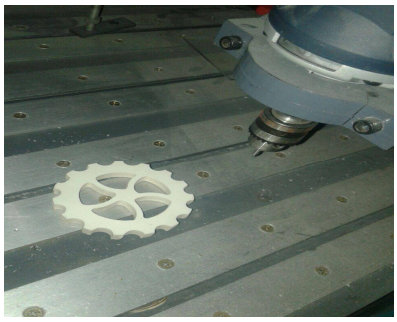


d

Figure 17-a,b,c,d Plotting capital E letter.

Two dimensions Cutting

2D cutting is the same as plotting and the same steps but they different in the tool that cutting used spindle. Figures (18) shows an example of 2D cutting.



a

b

Figure 18-a, b 2D cutting example

CONCLUSION

1. The proposed machine is easy to implement, inexpensive and comparable to the commercially available machines.
2. The overall cost of the plotter is below $500, which is quite cheap enough compared to the costs of similar machines having a starting price range of $5000-6000.
3. Easily can convert this machine in a multi-tasking machine by just changing the drill bits of the machine. This machine can best meet the broad range of application and needs of the industries in Iraq.

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