IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 15, Issue 2 Ver. I (Mar. - Apr. 2018), PP 49-55
www.iosrjournals.org

Low Cost Mini Multi-Tool CNC Machine

Mukul Gupta[1], Preety Gupta[2], Mudita Singh[3]& K.K.Yadav[4]
[1](*Mechanical Engineer, SRMGPC, Lucknow/ AKTU, U.P India)*
[2] *(I.T Engineer, SRMGPC, Lucknow/ AKTU, U.P India)*
[3]*(Assistant Professor Mechanical Engineer, SRMGPC, Lucknow/ AKTU, U.P India)*
[4]*(Assistant Professor Mechanical Engineer, SRMGPC, Lucknow/ AKTU, U.P India)*

Abstract: *The research paper is focused on the design and fabrication of mini multi-tool CNC (MMT CNC) machine. Research is aimed at the suitable selection of measuring parameters for On-machine measurement systems in order to reach an accurate and reliable quality control of the mechanical part. Due to the rapid growth of technology the usage & utilization of CNC machine in industries are increased. The fabrication of low cost CNC machine is used to reduce cost and complexity of machine. This paper deals with the design of automatic mini multi-tool CNC machine that can perform three machining operations i.e. Drilling, Shaping & Surface Machining.*

Date of Submission: 28 -02-2018 Date of acceptance: 17-03-2018

I. Introduction

The idea behind fabrication of low cost CNC Machine is to full fill the demand of CNC routers from small scale to large scale industries with optimized low cost. A major new development in computer technology is the availability of low-cost open source hardware, such as the Arduino microcontroller. An advantage of open source hardware is that a wide variety of ready-to-use software is available for them, therefore the prototyping and development times are drastically reduced. Moreover, a wide range of low-cost interfaces, sensors, and accessories such as Arduino shields are also available. However, for the development of low-cost educational models of CNC machines, such tools may be quite adequate from the viewpoint of machine control. In this paper, the development of a prototype is presented with following specifications:

- Low cost
- Easily operable
- Easy interface
- Flexible
- Low power consumption

The basic principle behind the proposed mechanism lies in the concept of simple controlling of motors with the help of android mobile as well as computer, the motors are attached with the machine through threaded shafts which is providing the CNC machine 3-axis motion by using motor controllers.

The idea of making this CNC machine is to reduce the complexity and cost of the CNC machine and further adding up, we can perform 3 machining operations at single station thus there is no need of changing the work piece every time and moving it to another machine.

The machine that we developed is a prototype model and it cost around Rs 12000. The actual machine cost by calculating the cost of motors and controllers we estimated it around Rs 90000.

The machine is still under development phase to make it fully automatic as it is a semi-automatic prototype model which is controlled by the use of android application through Bluetooth wirelessly as well as it can be controlled by the Laptop using the HyperTerminal software. The parameter on which the machine is working is the microcontroller that is connected to the motor controllers for each motors and the Bluetooth device is used to control the incoming and outgoing frequencies for controlling the machine by android phone as well as laptop.

II. Material And Methods

This prospective design and development of low cost mini multi-tool CNC machine has designed and fabricated in Department of Mechanical Engineering at SRMGPC Lucknow.

Study Design:

- Setup of this project is shown in figure above.
- Two side plates are used to hold the machine.
- Stepper motors will be used to move the tool holder left or right.
- The Tool holder carries three tools that can be used according to the requirement by rotating the tool holder disc precisely.
- The machine is able to work in 3 dimensions i.e. X, Y & Z
- By using a desktop application software this machine can be programmed to do a specific task

The component requirements are as follows:

i. **Wireless connectivity**

As stated above Android has connectivity functionality both of Wi-Fi & Bluetooth. For our requirement both connectivity protocols will work. But for economic and off-the-self availability of the Trans-receiver component we have chosen Bluetooth as our wireless connectivity protocol.

ii. Bluetooth

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication. This serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR blue-core 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature) The Bluetooth module HC-05 is a MASTER/SLAVE module by default the factory setting is SLAVE. The Role of the module (Master or Slave) can be configured only by AT COMMANDS. The slave modules cannot initiate a connection to another Bluetooth device, but can accept connections. Master module can initiate a connection to other devices. The user can use it simply for a serial port replacement to establish connection between MCU and GPS, PC to your embedded project, etc.

iii. Motor controller (L298)

The L298 is an integrated monolithic circuit in a 15- lead Multi-watt 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.

iv. Micro controller. There are number of popular families of microcontrollers which are used in different applications as per their capability and feasibility to perform the desired task, most common are 8051, AVR and PIC microcontrollers. The Atmel ATmega48/88/328 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega48/88/328 achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed.

The Atmel ATmega48/88/328 provides the following features: 4K/8K/16K bytes of In-System Programmable Flash with Read-While-Write capabilities, 256/512/512 bytes EEPROM, 512/1K/1K bytes SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte-oriented 2-wire Serial Interface, an SPI serial port, a 6-channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages), a programmable Watchdog Timer with internal Oscillator, and five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, USART, 2-wire Serial Interface, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or hardware reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption. The ATmega48, ATmega88 and ATmega328 differ only in memory sizes, boot loader support, and interrupt vector sizes. Table 2-1 summarizes the different memory and interrupts vector sizes for the three devices.

v. Stepper motor

A stepper motor or step motor or stepping motor is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller), as long as the motor is carefully sized to the application in respect to torque and speed. Switched reluctance motors are very large stepping motors with a reduced pole count, and generally are close loop commutated. Brushed DC motors rotate continuously when DC voltage is applied to their terminals. The stepper motor is known by its property to convert a train of input pulses (typically square wave pulses) into a precisely defined increment in the shaft position. Each pulse moves the shaft through a fixed angle. Stepper motors effectively have multiple "toothed" electromagnets arranged around a central gear-shaped piece of iron. The electromagnets are energized by an external driver circuit or a micro controller. To make the motor shaft turn, first, one electromagnet is given power, which magnetically attracts the gear's teeth. When the gear's teeth are aligned to the first electromagnet, they are slightly offset from the next electromagnet. This means that when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one. From there the process is repeated. Each of those rotations is called a "step", with an integer number of steps making afull rotation. In that way, the motor can be turned by a precise angle.

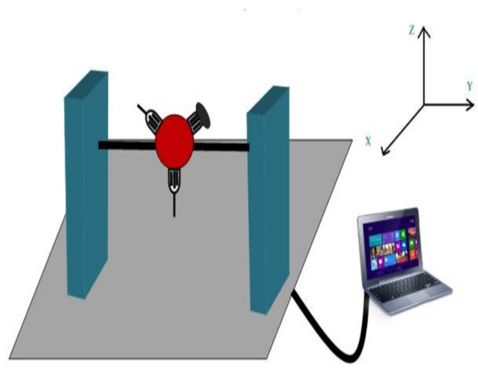

Figure 1 Design setup of MMT CNC

.

III. Hardware Requirements

The CNC machine prototype is the combination of electrical, mechanical & computer programming as well as android, the part requirements are as follows:

i. Threaded shaft or Lead screw- 4
ii. Nut- 4
iii. Square iron pipes
iv. Bearings- 16
v. Tool holder-1
vi. Tools
a. Drilling tool
b. Taping tool
c. Grinding tool
vii. Jonson motors- 3 motors 300rpm & 1 motor 10rpm
viii. Micro controller- ATMEGA!6
ix. Motor controller- L298
x. Bluetooth module- HC05
xi. Android phone
xii. Laptop
xiii. Software- Hyper terminal
xiv. Android application- Controller
xv. Adapters
xvi. Switches Subjects & selection method

IV. Design Specifications

1. Frame Total area of frame = 91.5X91.5 cm^2,Height = 15 cm 2. Three threaded shafts, Length = 92.5 cm, D = 1.5 cm 3. Bearings, Four bearings for x direction, D = 3.8 cm, Four bearings for y direction, D = 3.4 cm Eight bearings for carriage movement, D = 2.6 cm	4. Threemotors for movement = 300 rpm motor for tool advancing = 10 rpm 5. Microcontroller ATMEGA 16 6. Motor-controller L298 7. Bluetooth module HC-05 8.Three drill machines Speed- 3000 rpm 12V

V. Experimental Setup And Development

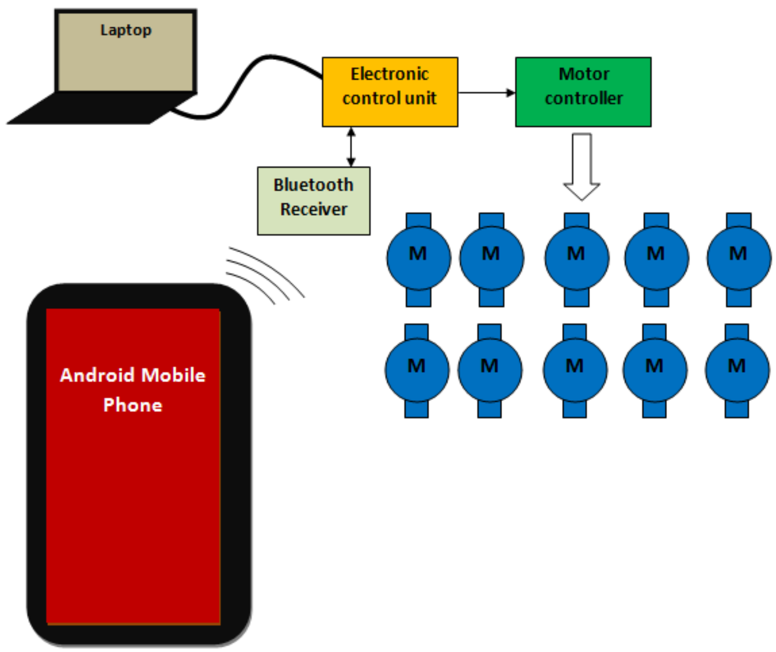

Figure 1 Schematic Diagram of MMT CNC

The General setup of the machine is shown in the above figure is the base model we have prepared. The configuration of the machine requires following steps:

Step 1: The microcontroller is attached with the 3 sockets as a power outlet & 3 adapters of 12 V supplies the power in the circuit, the circuit diagram below shows the connections

Step 2: The Microcontroller is connected to motor controllers. Motor controllers are connected to each motor powering the lead screws, the motor controllers are used to control the directions and timing of motors according to the instructions send by the user.

Step 3: Bluetooth module HC-05 is connected with the circuit and it is used to pair the android mobile phone with the machine and it is used to send the instructions by user to control the machine through the controller application installed in the android phone.

Step 4: When the device is paired with the Bluetooth module, we need to open the controller application, this application is specially made to control the circuits designed with ATMEGA 16 and HC-05 Bluetooth chipset, it has predefined set of functions and controlling tabs, each tab is linked with motors, tab needs to be clicked to control the specific motors according to the requirement.

Step 5: The tool holder contains 3 tools i.e. drilling tool, tapping tool & grinding tool which can rotate 360◦ & the 10 rpm motor controls the movement of the tool holder according to the need of the tool required for the machining.

Step 6: The work piece is held inside the bench vice assembly and we need to move the tool carriage where the work piece is been held, the tool carriage moves manually controlled by the user through the android phone by the controller application.

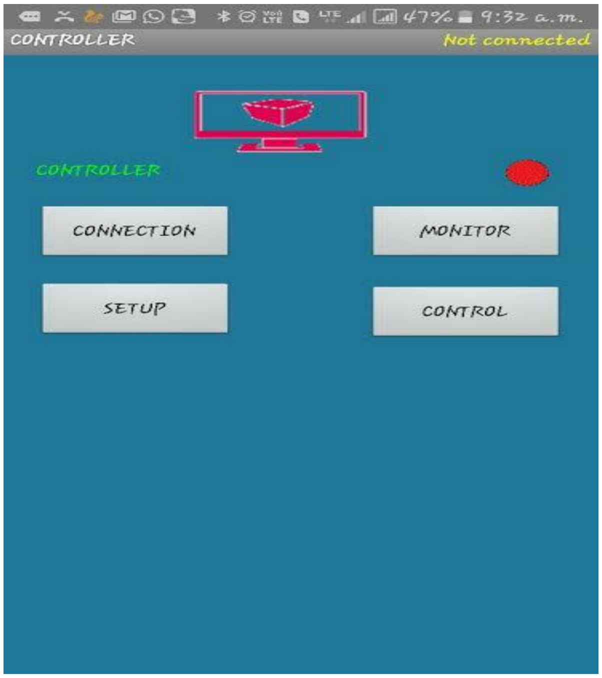

Figure 3 Controller Application Interface

VI. Working

- Switch on the circuit by connecting the adapters to the socket.
- Check the circuit is properly working by indication of LED lights on Bluetooth and motor controller.
- Connect the Bluetooth with laptop or mobile. Open the controlling terminal.
- Control the X, Y, Z axis motion by Arrow keys manually.
- Control the tool rotation and tool advancement by alphabets.
- Work according to the need of machining i.e. Drilling, tapping & surface machining.
- Place the work-piece on the wooden base by holding it firmly.
- Bring the tool at the place you want to do the machining.
- Perform machining and switch off the circuit.

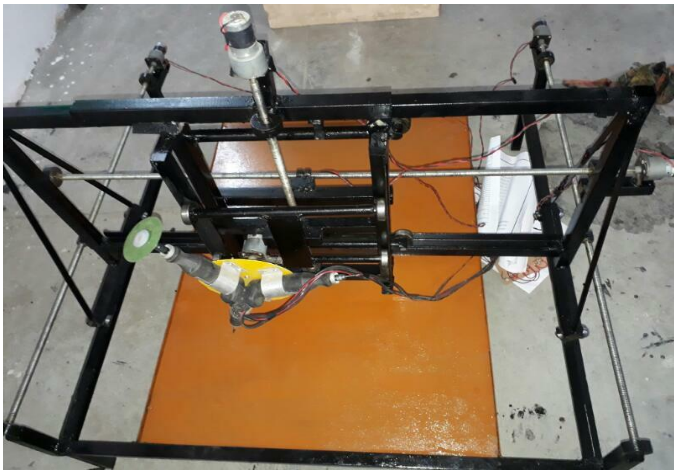

Figure 4 Actual Prototype of CNC machine

VII. Experimental Result

1. Work piece size: As a basis for further development of the drilling machine, the maximum component size (maximum travel along the axis) is selected as X = 80 cm. Y = 60 cm. Z = 20 cm.
2. Configuration selection: The different configurations are considered from fabrication point of view, and it is found that the gantry configuration is most suitable because of the following qualities:
a. Provides better rigidity.
b. Better accuracy.
c. Ease of operation and programming.
3.CNC machine components: The CNC machine is divided into three sub systems
a. The Mechanical structure.
b. The Electrical system.
c. The Program.
4. Design calculations:
a. X axis lead screw
The movement required is = 800 mm
For safer side selecting length of screw as = 500mm
Size = M10 x 1;Pitch, p =1 mm, Major diameter, d_o = 10 mm, Mean diameter, d = (d_o- p/2)= 9.5 mm
b. Y axis lead screw
The movement required is = 600mm
For safer side selecting length of screw as = 500 mm
Size = M10 x 1, Pitch, p =1 mm, Major diameter, d_o = 10 mm, Mean diameter, d = (d_o- p/2) =9.5 mm
c. Z axis lead screw
The movement required is = 200 mm
For safer side selecting length of screw as = 300 mm
Size = M10 x 1, Pitch, p = 1 mm, Major diameter, d_o= 10 mm, Mean diameter, d =9.5 mm
5.Power calculations: The load on the Y axis is maximum; hence the power required at Y axis sub assembly will be maximum. Hence the power required at Y axis lead screw is considered for selecting the motor.
The power required is calculated as:
Co-efficient of friction, μ=0.0015
$\tan \alpha = p/(\pi d) = 1/(\pi x10) = 0.0318$
$\tan \Phi = \mu = 0.0015$
Mass on lead screw in Y-direction, m_y = 5 kg
External force, $F_{ey} = m_y$ x g =5 x 9.81 =49.05 N
Frictional force, $F_{fy} = \mu$ x m_y x 9.81 (selecting μ=0.0015) = 0.0015 x 5 x 9.81 = 0.0736 N
Total force,$F_{ty} = F_{ey} + F_{fy}$= 49.05 + 0.0736 =49.1236 N

Tangential force required at the circumference of screw is:

$F_y = F_{ty} \times [\tan\alpha \text{ x } \tan\Phi]/[1-\tan\alpha \times \tan\Phi]$=49.1236 x [0.0318+ 0.0015] / [1-0.0318x0.0015] = 1.636 N
On the basis of tangential force torque required for screw rotation is,
$T_Y = F_Y \times d/2 + \mu \times F_{TY} \times R$ = 1.636 x 10/2 + 0.0015 x 49.1236 x (10/2) = 8.5484 N-mm = 0.0854 Kgf-cm
Speed of lead screw, N_y= 30 rpm.
Angular speed, $\omega_Y = 2\pi N/60$ = 3.14 rad/sec
Power, $P_Y = T_Y \times \omega_Y$= 0.0854 x 3.14 = 0.2681 W

VIII. Conclusion

This is competence development exercise, abinitio design starting from scratch to final Prototype in running condition by the undergraduate students. This report provides a clear insight in innovation and analysis of our machine. The goal was to simplify the overall design to make it more light-weight without sacrificing performance and durability of the machine. The goal was to simplify the overall design to make it more light-weight without sacrificing performance and durability.

References

[1]. Computer control of Manufacturing Systems by Yoram Koren,1983
[2]. Numerical Control of Machine Tools by S.J. Martin,1998.
[3]. Programming for Numerical Control" by Roberts Prentice,1968
[4]. Automated PCB Drilling Machine using DIP by Jagtap Priyanka Jalindar, Kolekar Ashwini Baburao, Chormale Pallavi Mahadeo and Prof.Trupti Chavan, ISJRD, Volume 4, Issue 02-2016
[5]. N.Balasubramanyam and Prof.Smt.G.Prasanthi "Design and Fabrication of an Automatic PC-Based Drilling Machine", HCTL Open International journal of Technology Innovations and Research, Volume 7, January 2014.
[6]. ShaikhNoorFarooque, Ansari Mohammed Faizan, JavedShaikh, Pragati Pal "Automated Pcb Drilling Machine with Efficient Path Planning", International Journal of Advanced Research in Computer and CommunictionEnginnering, Vol 4, Issue 4, April 2015.
[7]. ZulkifliTahir, NurAzman Abu, Shahrin Sahib, NannaSuryanna Herman, "CNC pcb drilling machine using novel natural approach to euclindeantsp", UniversitiTeknikalMalaysia, IEEE 2010.
[8]. madekar, kajal j., et al. "automatic mini cnc machine for pcb drawing and drilling." (2016).
[9]. linggarjati, Jimmy, and Rinda Hedwig. "Manually interchangeable heads of homemade computer numerical control machine." Internetworking Indonesia Journal 1.1 (2013).
[10]. Mr. Wright, DE. Platts, DB.French, G. Traicoff, MA. Dupont, and GA. Head,"CNC control system patents," us patent 545393, sept 26,1995
[11]. Torjus spilling "Self-improving CNC milling machine" University of Oslo (2014)

Mukul Gupta "Low Cost Mini Multi-Tool CNC Machine.IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , vol. 15, no. 2, 2018, pp. 49-55