DESIGN AND FABRICATION OF PORTABLE MINI CNC ROUTER FOR SHOP FLOOR CARVING APPLICATIONS

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ABSTRACT-Routers are the most used computer numerically controlled machines for cutting different various materials are aluminium,acrylic sheet , woodworking, generated by a software are available in a range of configurations from a number of manufacture industry.CNC Carving router system which was used in CNC carving machine was normally used for engraving, woodworking, drilling, 3D milling, PCB drawing, aerospace making applications. It can be used with design art cam software. The software used to control this CNC carving machine to control system by Arduino nano microcontroller in Grbl software, frame can be used with aluminum material. It this material is used because light weight. The main aim of this project is to reduce cost of the machine, it should be develop for educational purpose, and everyone can operate, this machine is portable, light weight, laser engraving, small sizes, and USB interface low cost and simple to use.

Keywords- Lead screw, ball bearing, Arduino Nano Microcontroller, Nema17 Stepper motors, A4988 driver, Spindle motor, Grbl software.

I. INTRODUCTION

In the modern manufacturing industries are CNC systems, component is design and fabrication is highly automated all using computer aided design, computer aided manufacturing and which control the function of a machine tool using G-coded and M-coded instruction processed by computer system

It is the combined charactheristics of the electric control as well as the mechanical design of the machine tool itself that determine the final accuracy and productivity of the CNC machine tool system

The main aim of our project was to make the whole machine as low cost as possible. The component selection plays an important role in the functionality and cost optimization of the CNC router. The components are selected in such a way that they give greater functionality with affordable cost. The components described in a detail in two sections one is Mechanical which includes first we select the aluminum material is cheaper and reliable material compare to other materials , ball/lead screws, ball bearings, linear ball bearings used, shaft couplers, end support shafts, linear rods etc. The second is Electronics which includes the description about the power supply selected and how is been used, microcontroller board, stepper motors, stepper driver boards, spindle motor etc.

II. Objective of paper

The idea behind design and fabrication of Portable CNC router 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 nano microcontroller platform and the Raspberry PI single board compute. An advantage of open source hardware is that a wide variety of ready-to-use software is available for them on the Web; Moreover, a wide range of low-cost interfaces and accessories such as Arduino shields are also available. Predating the open source hardware, several useful open source software tools have been available in the area of CAD/CAM/GRBL Control software. However, for the development of low-cost educational models of CNC router, such tools may be quite adequate from the viewpoint of machine control. In this project, the development of portable mini CNC Router using Arduino nano-based control system. This system reduces the cost of machine and flexibility.

- It can be achieved by implementing the compact design, easy configurable and easily available mechanical, electronics and open source software platforms.

III. METHODOLOGY

This system can be divided in to three systems. A mechanical system gets control signals from the electronics systems which ultimately results in actuation of motors. Electrical and Electronics systems gets the set of commands from software systems and generates controls for mechanical systems

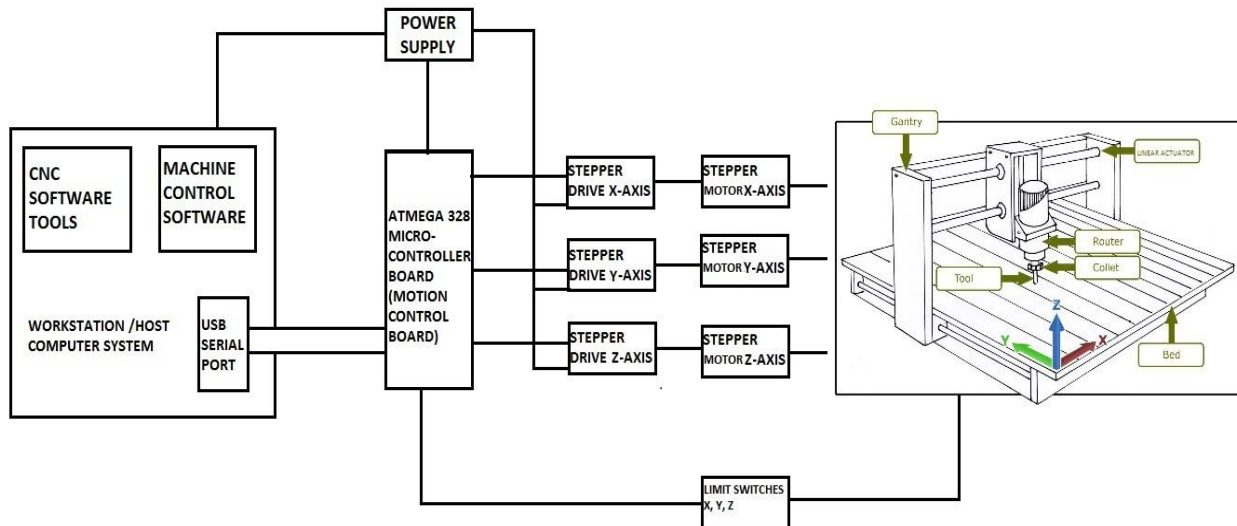The detail explanation of three systems has been explained along with proper components

Fig 1. Block diagram of Overall process in Portable Mini CNC router

VI.MECHANICAL SYSTEM

The mechanical system which is assembled in such a way that the 3-axis movement is achieved by using the linear rails assembled with linear bearings. Stepper motors are mounted to the each axis which is source of motion acted according to the control signal generated from the electronics circuit. Each stepper motor is coupled through the shaft couplers to each of the Lead/Ball screw of each axis which is responsible for converting the rotational motion of the stepper motor to linear motion. The linear motion of each axis is carried away smoothly by the linear rail assembly connected to the each axis which is capable of load carriers and allows linear motion in each axis. The controlled motion in each axis is achieved directly by controlling the rotation of the stepper motor. The speed of the motion in each axis can also be controlled by direct control of the speed of the stepper motor by giving required control signals.

A.ANGLE BRACKET:

Fig 2 Angle Bracket

* It is used to join two aluminum metal stands fit together for assemble body frame of the router

B. FITTED FRAME

Fig 3. Fitted frame

C. LEAD SCREWS WITH COPPER NUT

Fig 4.lead screw with copper nut

D. LINEAR BEARING

Fig 5.Linear bearing

E. FLEXIBLE SHAFT COUPLINGS

Fig 6. Flexible Shaft Couplings

V. ELECTRICAL AND ELECTRONICS SYSTEM

Electronics system is responsible for generating control signal to the stepper motors which will guides the motion of tool path in each direction or all 3 axis. Electronics system is comprises of

A. POWER SUPPLY

Power supply is heart of the CNC system which converts the AC voltage to Dc voltage and supplies required voltages to the corresponding devices. Microcontroller board receives 5v supply whereas the stepper motor board receives 12v.

B. MICROCONTROLLER BOARD

Fig 7.Arduino nano microcontroller in grbl0.9i control board

The motion control of the router is not possible without microcontroller; we can use arduino nano board with Atmel 328p microcontroller. Atmel 328p is a 32bit 30 pin microcontroller programmable with arduino codes. It acts as brain of this

CNC system which receives the commands from the software system from computer software connected through the USB serial port.

G. NEMA 17 STEPPER MOTOR

Fig 8.Stepper motor

- The **Nema 17 4.2 kg-cm stepper motor** provides excellent response to starting ,stopping and reversing pulses from stepper motor driver
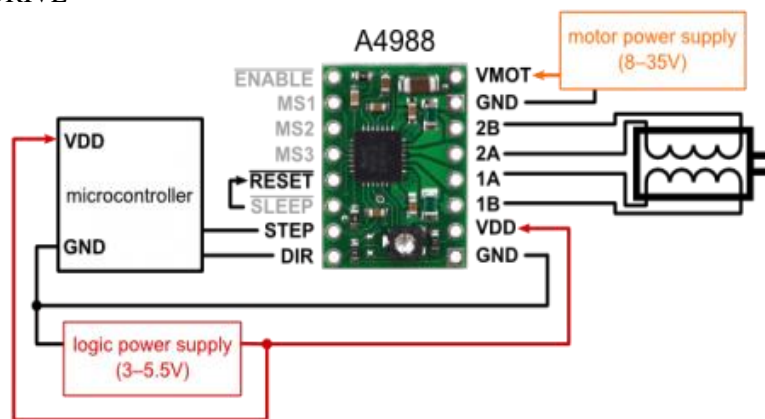
C.STEPPER MOTOR DRIVE

Fig 9. (a)A4988 Wiring diagram

- **A4988** is micro-stepping drive designed for smooth and quiet operation is chosen to drive the NEMA 17 stepper motor.
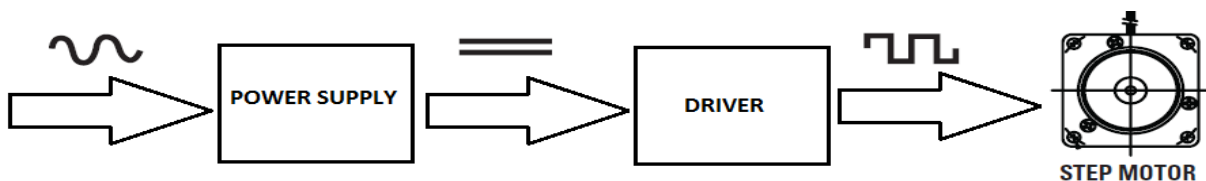
Fig 9. (b)Work flow in Stepper motor

F. SPINDLE MOTOR WITH TOOL CHUCK

Fig 10.Spindle motor with tool chuck

- **Spindle motor** is a high speed DC motors which is responsible in cutting the work piece the tool is placed in the chuck attached to the spindle motor and the motor is controlled over from the microcontroller board through the spindle motor driver 775 DC motor
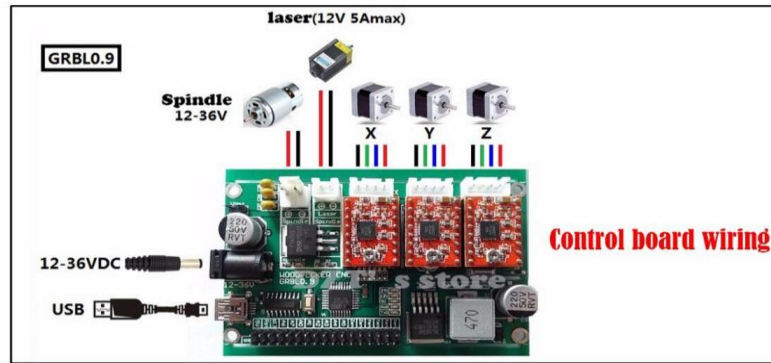
D.CONTROL BOARD WIRING

Fig 11.Grbl 0.9 Control board wiring

- **Control board** is used to control the whole machine, movement direction of xyz axis stepper motors and spindle motor respectively

VI.SOFTWARE AND CODING SYSTEM

The tool chain of CNC based manufacturing system as shown in below fig 12.The CAD software is used to generates the component design which is then transferred to the CAM software which generates the M and G codes for the input of the Grbl control software which then converts to the machine language which is sent to the Arduino nano to achieve the motion of the router

Fig 12. Software Tool Chain

1) **Cad Software**: CAD is used to generate design, drawings, 3d design for the CAM software using .prt and other similar formats based on parameters.

2) **Cam Software**: CAM is used to convert the cad file to the.stl format for interpretation in machine language. A CAM tool generates G-code. We can use to chosen Art CAM software for design work components

3) **GRBL control software:** GRBL control is used to send the G-code files to arduino nano controller G-code Sender will take a G-code program in file and then send it line-by-line. The G-codes will send the data via serial ports through USB cable between the computer and microcontroller. G-Code universal sender is software that is designed to send G-Code to CNC router.
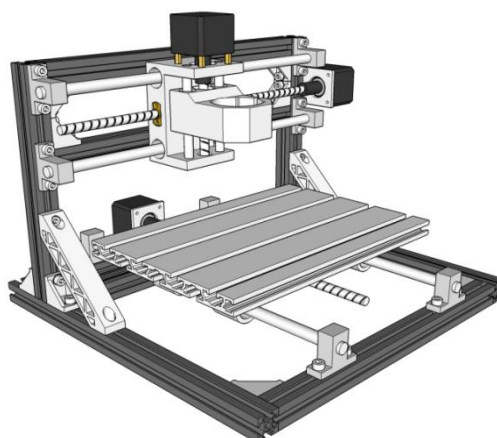
VII. STRUCTURE DESIGN OF PORTABLE MINI CNC ROUTER

Fig 13.CNC Structure design

- In this project work CNC router can be design fixed router with movable work table

VIII. ASSEMBLY OF MACHINE STRUCTURE

The detailed fabrication procedure of the portable mini CNC router is described; start with the selection of various shelf components. After arrange all components and accessories required for assembling, the procedure of making the router is listed below step by step

- Frame installation from base to top
- XY axis support base installation
- Y axis installation
- XY axis stepper motors mounting with bracket
- XZ axis component installation
- XY axis lead screw assembly with copper nut
- Shaft coupling assembly
- XY axis bearing installation
- Install control board
- Installation of motors and limit switches
- Stepper motors are installed to each of the xyz axes respectively and connected to the lead screw through the shaft couplers.
- And place the spindle motor in the holder which is fixed z-axis stand.
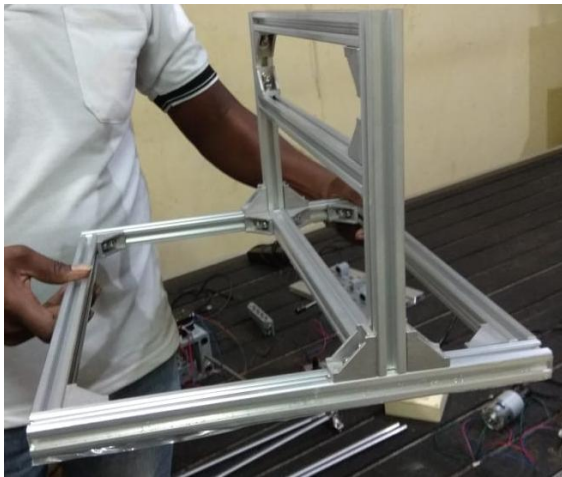
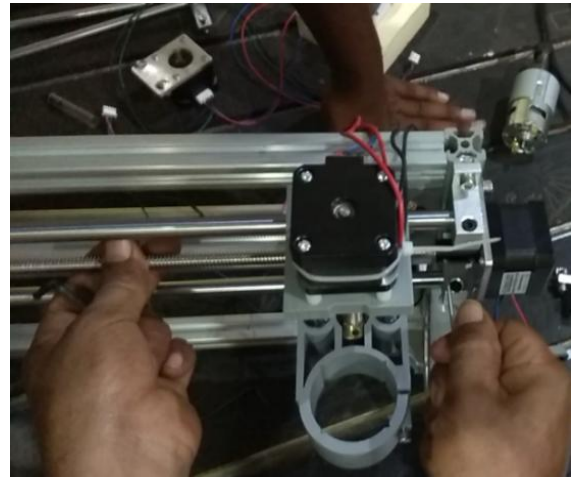
Fig 14. Frame installation from base to top

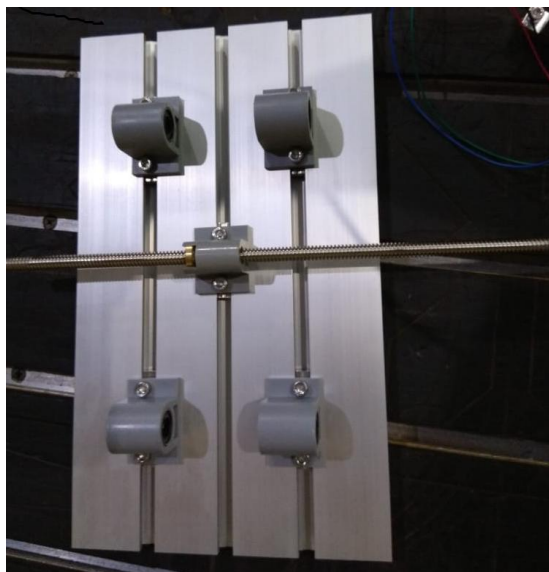Fig 15. XY axis components installation

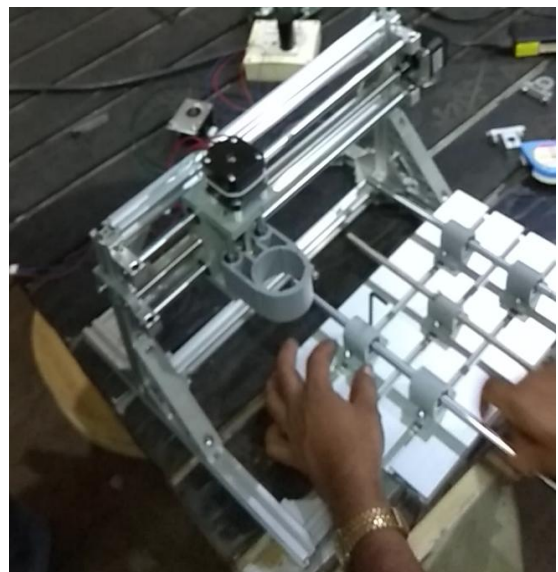Fig 16. Lead screw assembly on y axis with copper nut

Fig 17. XY axis bearing installation
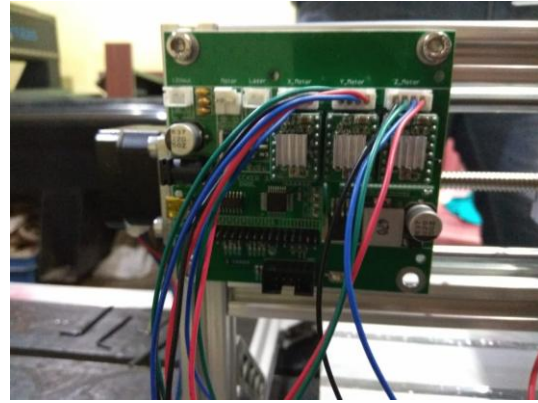
Fig 18. Stepper motor mounting on XY axis
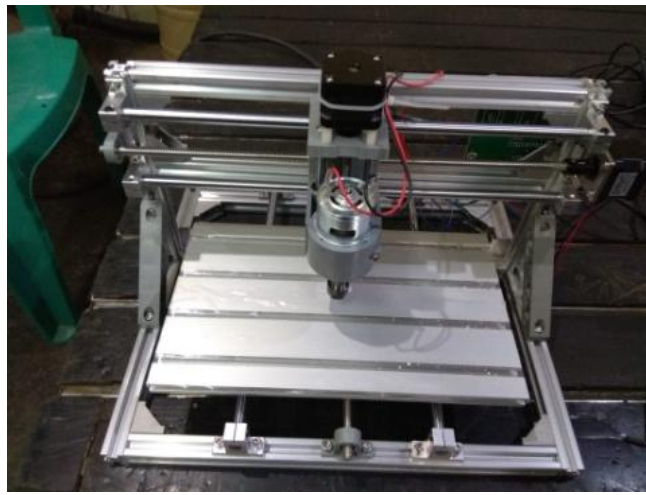

Fig 19. Install Control Board Wiring

Fig 20.Fabricated Model of CNC Router

IX. EXPERIMENTAL SETUP FOR TEST

A. Overall setup images of the project

Fig 21.Working setup laptop with fabricated mini CNC route

B. Before work on wood plate, we can take some important steps

1. Install Grbl control software in laptop/ PC
2. Open Grbl Control software to connect the machine, choose the correct port：
3. After adjusting the machine, open the carving file to check where the zero point is, usually at the lower left corner, the same as the 2 test codes.
4. Locate the machine to the lower left corner of the work piece first, and then lower the cutter and the spindle must be turned on. Slow it down when the cutter is close to the work piece, gently adjust it to the surface.

5. Important! After lowering the cutter, click "XY zero" and "Z zero". Then you can click "start" to carve
6. Tips: It is better to run the machine without any work piece first. Test it before you start formal carving.
7. Zero setup is most important setup to obtain an accurate geometry of the work piece
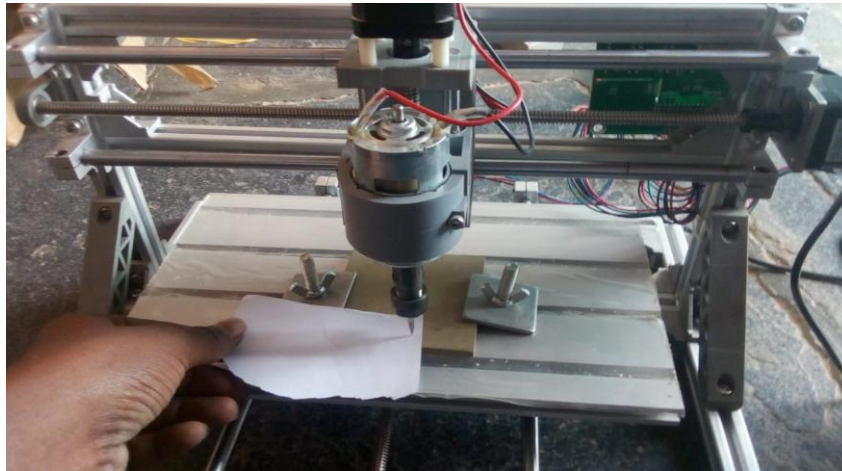
C. Letter iphone test on Soft wood Plate
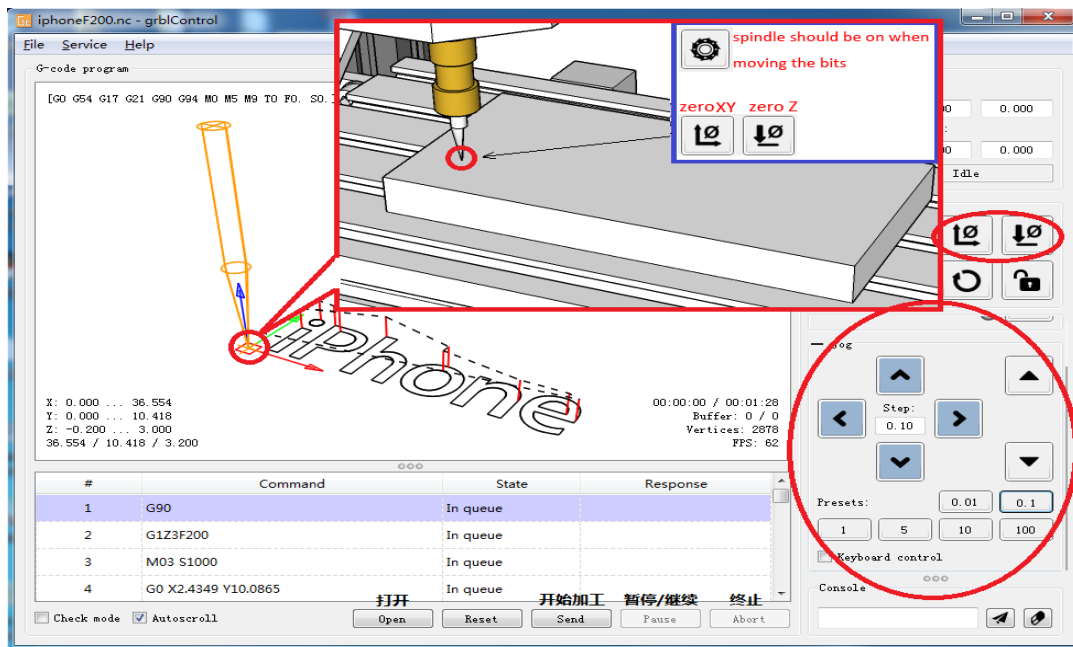

Fig 22.Tool offset of the work plate

Fig 23.Grbl Software for carving router

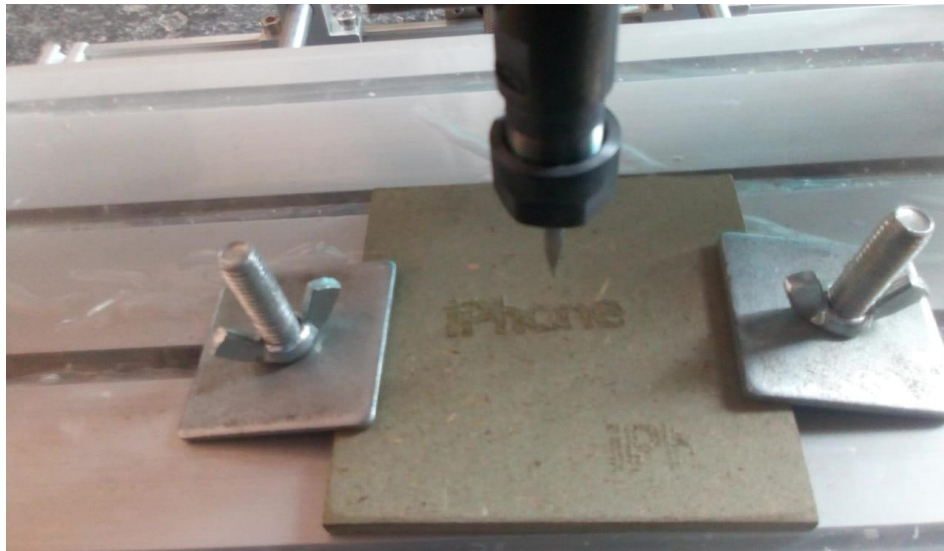Fig 24.Operation on work soft wood plate

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Fig 25.Completed operation on wood plate

X. RESULT

The results shows that the considerable tolerances is achieved and great dimensional accuracy with surface flatness, perpendicularity and circularity is achieved with less tolerance and at lower budget. The achieved objectives are:

*   Lower Cost

*   Easy Operable

*   Easy Programmable

The results of the Fabrication of portable mini CNC router which is tested for straightness test, perpendicularity test, and circular tests conducted on paper. The errors are measured in axes which gives that there is little tallness in X-axis than Y-axis caused due to error in assembling. The G code programs are validated and tested on the paper and also machined on wood and metal such as aluminum and gives better results and considerable tolerance

XI.CONCLUSION

From this project, we learned the principle of CNC router. We gained better understanding in the modes of operation of CNC router. There is various type of modern CNC routers use in industry. We would conclude that it gives an idea for the beginners to understand on how the CNC routers work virtually. The price of this machine at the time of its manufacturing and fabrication was just below Rs 50,000/-only. As this is a low price as compared to other machines, so poor fabricators can also purchase this machine to increase their production.

XII.SCOPE FOR FUTURE

It is hoped to extend this work in future to portable mini CNC router spindle can be replaced by laser make it work like laser engraving. It is planned to scale up the portable CNC router in terms of size, use more powerful motors, strengthen the frame, worktable and cubic body with materials like acrylic sheet, aluminum or cast iron, and augment the CNC control software with software for simulation ahead of actual run.

XIII. ACKNOWLEDGEMENT

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